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The Palaeontology Newsletter

Contents

Reminder: The deadline for copy for Issue no. 103 is 10th February 2020.

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Editorial

As the boreal winter descends those of us in higher latitudes are increasingly looking forward to the Valencia meeting, where even in December temperatures can exceed 20ºC. To tide you over before then we have another bumper issue of the *Newsletter*.

Warmer places appear throughout the issue. **Jan Zalasiewicz** discusses the habitability of the early Earth now that the Late Heavy Bombardment may have occurred earlier than previously thought, opening the window for (modern) life's origins to reach even further back in time. This time the Spotlight on Diversity shines on **Catalina Pimiento**, who focuses on the current climate crisis and the intersection between palaeontology and climate activism. Our Legends of Rock piece – on avian palaeontologist Hildegarde Howard – is penned by **Fernanda Castano**. Hildegarde spent her entire career in the Southern Californian climate, working on the famous Rancho La Brea fauna.

The other kind of rock makes a double appearance in this issue. **Jesper Milàn**, **Mats E. Eriksson** and **Achim G. Reisdorf** write about the success of a touring exhibit of fossil species named after music stars, an exhibition that has appeared not just in museums but also at heavy metal festivals. Mats has even written a book on the subject, and this appears in the Book Reviews, courtesy of **Christian Klug**.

The rebooted Careers Q & A continues with **Harrie Drage**, who talks about her transition from academia to publishing, and this issue's *A Palaeontologist Abroad* comprises three early career researchers, **Ana Balcarcel**, **Gabriela Sobral** and **Pia Viglietti**, giving their perspectives on palaeontological life in Switzerland, Germany and the United States, respectively.

Finally, I would like to highlight a couple of upcoming pieces you can expect in issue 103. Firstly, **Rachel Warnock** – who has been doing an excellent job filling the new Diversity Officer role – has led a team of authors in appraising the gender breakdown of *Palaeontology* authors across the entire journal's run. Expect a report summarizing the data next issue. Secondly, **April Wright** (Southeastern Louisiana University) has agreed to replace **Mark Bell** with a new series on morphological phylogenetics. Enthusiastic members can get a head start by checking out her recent paper, "A systematist's guide to estimating Bayesian phylogenies from morphological data" (Wright 2019)[1].

Graeme Lloyd
Newsletter Editor
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[1] Wright, A. M., 2019. A systematist's guide to estimating Bayesian phylogenies from morphological data. *Insect Systematics and Diversity*, **3.3**, 2.

Association Business

Annual Meeting 2019

Notification is given of the **63rd Annual General Meeting**, which will be held during the Annual Meeting at the University of Valencia, Spain, on 19th December 2019, following the scientific sessions.

AGENDA

1. Apologies for absence
2. Minutes of the 62nd AGM, University of Bristol *
3. Trustees Annual Report for 2018 *
4. Accounts and Balance Sheet for 2018 *
5. Election of Council and vote of thanks to retiring members
6. Report on Council Awards
7. Annual address

* Papers pertaining to these agenda items were published in the previous *Newsletter*, available online at <**www.palass.org**>, and are printed in full in the *Programme and Abstracts of the Annual Meeting* which will be distributed to delegates in Valencia.

Nominations for Council

At the AGM in December 2019, the following vacancies will occur on Council:

- President-elect
- Vice President
- Chair of the Editorial Board
- Editor Trustee
- Outreach Officer
- Internet Officer
- Ordinary Members (four vacancies)

Nominations received by the deadline are as follows:

- President-elect: Prof. P.J. Orr*
- Vice President: Dr F.L. Gill*
- Chair of the Editorial Board: Dr B.H. Lomax*
- Editor Trustee: Prof. N.J. Butterfield*
- Outreach Officer: Ms Z.E. Hughes*, Ms E. Wallace
- Internet Officer: Dr R. Garwood*
- Ordinary Members (four vacancies): Dr S. Giles*
  Dr T.H.P. Harvey*
  Dr L. Hyde
  Dr T. Clements

* denotes Council nominations.

As there are two nominations for the one Outreach Officer post there will be an election at the Annual General Meeting, as per clause 13(3) of the Association Constitution. This will take place at the AGM as per clause 11(6). There will be an e-mail ballot of members not registered for the Annual Meeting, which will be carried out in accordance with clause 11(7) of the Association Constitution. Voting instructions will be sent by e-mail to those members not registered for the Annual Meeting in early November. The statements of interest for the posts by the two nominated persons are as follows.

Zoë E. Hughes

I am passionate about palaeontological outreach and I believe that I am at a perfect point in my career to take on this responsibility. I organize numerous events in the NHM, and in my role of Programme Secretary of the Geological Curators Group. I am adept at managing a range of responsibilities across my roles. I am regularly invited into schools to speak to students. I am experienced in conveying complex concepts to children, and adults of all ages, regardless of prior knowledge. I have been doing outreach and creating activities in a variety of guises for around eight years, and in that time have spoken to thousands of people.

I have been successful in educating many people about brachiopods, a phylum of which most people outside academia are unaware. As part of this I have been engaging children with their role in climate change research, a topic which is of massive concern to young people. If I were to be elected to the position of Outreach Officer I would like very much to work with the public engagement group to increase outreach to schools in deprived areas, in order to raise diversity in the sector from grassroots levels and bring greater awareness of palaeontology to the masses. Going and speaking in schools, at fossil festivals and through internet channels, it is possible to reach those who might otherwise miss their calling in life, making fossils truly for everyone.

Elspeth Wallace

I am a passionate science communicator and would relish the opportunity to increase public engagement with palaeontology as the PalAss Outreach Officer. I have been involved in palaeontological outreach throughout my university career and am currently specializing in geoscience EPE (education and public engagement) in my current position as Education and Engagement officer for iCRAG (Irish Centre for Research in Applied Geosciences). I have extensive experience in the development and delivery of palaeontological outreach workshops and activities. I am also well versed in the development, logistics and delivery of science festivals such as Science X which engaged with 83,000 people in total this year. I am particularly passionate about promoting women and under-represented groups in science. In my experience engaging with these groups, I have learned that effective EPE cannot be one sided, where a scientist goes into a room and talks to people. It must be a two-way communication through which knowledge can be transferred and ideas developed between various stakeholders. I hope to facilitate this scientific conversation through the role of Outreach Officer. I am dedicated, determined and enthusiastic and believe I will make a good addition to the PalAss Council.

Awards and Prizes

The Palaeontological Association recognizes excellence in our profession by the award of medals and other prizes. The Association sees its lists of medal and award winners as a record of the very best palaeontologists worldwide, at different career stages, and offering different kinds of contributions to the field. The Association stresses the importance of nominations, and encourages all members to make nominations.

Lapworth Medal

The Lapworth Medal is awarded by Council to a palaeontologist who has made a significant contribution to the science by means of a substantial body of research; it is not normally awarded on the basis of a few good papers. Council will look for some breadth as well as depth in the contributions in choosing suitable candidates.

The candidate must be nominated by at least two members of the Association and the application must be supported by a résumé (single sheet of details) of the candidate's career, and further supported by a brief statement from each of two nominees. A list of ten principal publications must accompany the nomination. If a candidate has taken time out from their professional career for family or other purposes, this should be highlighted.

Nominations must be compiled into a PDF file of less than 10 MB and uploaded to the PalAss website. The award will be considered by Council at its May meeting and awardees will be invited to a ceremony at the Annual Meeting in December. Awards will also be announced in the *Newsletter*, on the Association website and through social media. Council reserves the right to not make an award in any year.

Nominations are invited by **31st March** each year.

President's Medal

The President's Medal is a mid-career award given by Council to a palaeontologist who has had between 15 and 25 years of full-time experience after their PhD (excluding periods of parental or other leave, but not excluding periods spent working in industry) in recognition of outstanding contributions in his/her earlier career, coupled with an expectation that they will continue to contribute significantly to the subject in their further work.

The candidate must be nominated by at least two members of the Association. Nominations must include a single page that summarizes the candidate's career, further supported by a brief statement from the two nominating members. A list of ten principal publications must accompany the nomination. Letters of support by others may also be submitted. If a candidate has taken time out from their professional career for family and other purposes, this should be highlighted.

Nominations must be compiled into a PDF file of less than 10 MB and uploaded to the PalAss website. The award will be considered by Council at its May meeting and awardees will be invited to a ceremony at the Annual Meeting in December. Awards will also be announced in the *Newsletter*, on the Association website and through social media. Council reserves the right to not make an award in any year.

Nominations are invited by **31st March** each year.

Hodson Award

The Hodson Award is conferred on a palaeontologist who has had no more than ten years of full-time experience after their PhD (excluding periods of parental or other leave, but not excluding periods spent working in industry) and who has made a notable contribution to the science.

The candidate must be nominated by at least two members of the Association and the application must be supported by an appropriate academic case, namely a single page of details on the candidate's career, a list of principal publications, and a brief statement from each of the two nominees. If a candidate has taken time out from their professional career for family or other purposes, this should be highlighted.

Nominations must be compiled into a PDF file of less than 10 MB and uploaded to the PalAss website. Nominations will be considered by Council at its May meeting and awardees will be invited to a ceremony at the Annual Meeting in December. Awards will also be announced in the *Newsletter*, on the Association website and through social media. Council reserves the right to not make an award in any year.

Nominations are invited by **31st March** each year.

Mary Anning Award

The Mary Anning Award is open to all those who are not professionally employed in palaeontology but who have made an outstanding contribution to the subject. Such contributions may range from the compilation of fossil collections and their care and conservation, to published studies in recognized journals.

The candidate must be nominated by one or more members of the Association with a short statement (up to one page of A4) outlining the candidate's principal achievements, compiled into a PDF file of less than 10 MB and uploaded to the PalAss website. Nominations will be considered by Council at its May meeting and awardees will be invited to a ceremony at the Annual Meeting in December, although the award may be presented at another time and place on request of the awardee. Awards will also be announced in the *Newsletter*, on the Association website and through social media. The Council reserves the right to not make an award in any year.

Nominations are invited by **31st March** each year.

Gertrude Elles Award

The Gertrude Elles Award is to promote high-quality public engagement in the field of palaeontology. The award is made by Council for high quality, amateur or institutional, public engagement projects that promote the discipline. Nominated projects can include museum displays and exhibitions, outreach programmes to schools and/or communities, art/science collaborations, digital initiatives, or any other programme that falls broadly under the heading of public engagement with palaeontology.

Nominations must consist of a brief supporting case and a portfolio of up to four images. The supporting case must outline:

- the aims of the project
- the nature of the target audience
- the available budget and funding sources
- visitor/audience numbers
- the results of project evaluation to demonstrate the quality and effectiveness of the project
- links to any digital components

Self-nominations are permitted, and the nominators and proposed recipients do not need to be members of the Association. Nominations will be considered relative to the scale of the institution and the available project budget.

The supporting case and the portfolio of images must be compiled into a PDF file of less than 10 MB and uploaded to the PalAss website. The award will be considered by Council at its May meeting and winners will be invited to the award ceremony at the Annual Meeting in December. Awards will also be announced in the *Newsletter*, on the Association website and through social media. Council reserves the right to not make an award in any year.

Nominations are invited by **31st March** each year.

Honorary Life Membership

Honorary Life Membership recognizes individuals whom Council deem to have been significant benefactors and/or supporters of the Association. Recipients will receive free membership for life.

Nominations from one or more members of the Association must be compiled into a PDF file of less than 10 MB and uploaded to the PalAss website. The award will be considered by Council at its May meeting and announced at the AGM. The award will also be announced in the *Newsletter*, on the Association website and through social media.

Nominations are invited by **31st March** each year.

Annual Meeting President's Prize and Council Poster Prize

These are awarded for the best talk and best poster at the Annual Meeting. All student members of the Palaeontological Association, and all members of the Association who are early-career researchers within one year of the award of a higher degree (PhD or MSc), excluding periods of parental or other leave, are eligible for consideration for these awards. Individuals may nominate themselves for consideration when submitting abstracts for the meeting. Each prize consists of a cash award of £200, and is announced immediately after the oral sessions at the end of the Annual Meeting.

Best Paper Awards

This has been awarded since 2015 for the best papers published in *Palaeontology* and *Papers in Palaeontology* during the calendar year. Corresponding authors of winning papers are offered 'gold open access' paid for by the Association for one nominated paper submitted to *Palaeontology*/ *Papers in Palaeontology* within the following 18 months (and subsequently accepted). In the case of joint-authorship papers, the corresponding author can, by agreement, transfer the prize to one of the co-authors. All eligible papers are automatically considered for this award by the Editor-in-Chief and Editorial Board members, and their decision is announced at the Annual Meeting.

Undergraduate Prize Scheme

The Undergraduate Prize Scheme annually invites all university departments where a palaeontology course or module is taught after the first year as part of a degree programme to recommend one of their undergraduate students to receive this award. The award consists of a certificate and free membership of the Association for the rest of the year in question, plus the following calendar year. It provides electronic access to both of our journals, postal copies of the *Newsletter*, and all the other advantages of membership. Receipt of the award also looks good on a recipient's CV.

Departments may use any criterion for selection, though most prefer to use the scheme as an acknowledgement of best performance in a relevant exam or project. Only one nomination will be accepted from any one institution in each calendar year. The nominee must be an undergraduate student, not a postgraduate, when they are selected. Normally the award is made to a student in their penultimate year of study, but a final-year candidate may be chosen if this is deemed more appropriate for the department in question.

Contact <**executive@palass.org**> with the nomination (name and e-mail address) and we will arrange to sign up the student as a member and send them a certificate. There is no deadline for this award.

Innovations in Palaeontology Lecture Series and the PalAss Exceptional Lecturer

The Innovations in Palaeontology Lecture Series, to be given by the **PalAss Exceptional Lecturer**, aims to promote palaeontology to the wider academic community and to recognize excellence in research among palaeontologists. The PalAss Exceptional Lecturer is selected in a competitive process.

This scheme aims to:

- Improve the dissemination of cutting-edge palaeontological research to the broader academic community.
- Raise the profile of palaeontology within the Earth sciences and related fields.
- Recognize outstanding research and science communication in palaeontology among members of the Association.

Format of the scheme:

- One PalAss Exceptional Lecturer will be selected each year in a competitive process.
- The PalAss Exceptional Lecturer will be expected to give five lectures at five different institutions over a nine-month period.
- The successful applicant will receive the Innovations in Palaeontology Lecture Series Grant, which will be administered by the home institution of the PalAss Exceptional Lecturer.
- The Innovations in Palaeontology Lecture Series Grant may only be used to pay the reasonable travel costs incurred by the PalAss Exceptional Lecturer to visit each of the host institutions (up to £2,000 for the total Innovations in Palaeontology Lecture Series with a maximum of £500 for any individual lecture). The host institutions will cover costs for accommodation (where necessary) and hospitality.
- Any academic institution (universities and/or museums) from any country can apply to participate in the Innovations in Palaeontology Lecture Series as a host institution.
- Any unused funds must be returned to PalAss after delivery of the final lecture. Should the PalAss Exceptional Lecturer move institutions within the timeframe of the lecture series, any unspent funds must remain available to the PalAss Exceptional Lecturer.
- Applications to be a PalAss Exceptional Lecturer will be strengthened if the applicant agrees to submit a paper as a review article for possible publication in *Palaeontology*.

Eligibility and selection process of the PalAss Exceptional Lecturer:

- Eligible candidates will have a PhD in palaeontology or a related field.
- Applicants can reside in any country, but must be members of the Association.
- Candidates must self-nominate.
- To self-nominate, a two-page CV, full list of publications and statement of motivation (max. 300 words) must be submitted via the Association's webpage as a single PDF file (max. 8 MB), *along with* an outline of a proposed seminar topic as EITHER a 60-second video summary (in mp4 format; max. size: 30 MB) OR two powerpoint slides (in ppt/pptx format; max. size: 30MB).

- The PalAss Exceptional Lecturer will be chosen based on career track record, including research impact (relative to their career stage) and oratorical skills.

Selection of host institutions:

- Institutions interested in participating in the Innovations in Palaeontology Lecture Series should apply via the PalAss webpage and suggest a time-frame within which the lecture should be given.
- The PalAss Exceptional Lecturer will receive the list of potential host institutions after the 1st May deadline, and will choose their preferred hosts and liaise directly with them. Applications after 1st May will be considered depending on the remaining availability.

Expectations for host institutions:

- Each lecture must be widely advertised across the host institution. We particularly encourage advertisement of the Innovations in Palaeontology Lecture Series on social media.
- Host institutions are expected to pay for hospitality and offer a meal in a social environment to the PalAss Exceptional Lecturer.
- If the PalAss Exceptional Lecturer has to travel more than three hours to the host institution or cannot return home at a reasonable time, the host institution must offer at least one night of accommodation.

Deadlines each year:

- In order to broaden the pool of applications, the Council of the Palaeontological Association has decided to amend the eligibility and selection process of the PalAss Exceptional Lecturer so that a summary of the proposed seminar can now be submitted either as a two-slide powerpoint presentation or as a video of up to 60 seconds.
- 1st November: Deadline for nominations for the PalAss Exceptional Lecturer.
- December: The PalAss Exceptional Lecturer will be announced at the Annual Meeting.
- February: The call for host institutions to participate in the Innovations in Palaeontology Lecture Series will be published in the spring *Newsletter*.
- 1st May: Deadline for applications from host institutions.
- September – May: delivery of lectures.

Uwe Balthasar
University of Plymouth

GRANTS

Palaeontological Association grants are offered to encourage research, education and outreach through different means. Undergraduates, early-stage researchers, and otherwise unfunded persons are given special encouragement to apply. All of these awards and grants are core to the charitable aims of the Palaeontological Association. A full list of the Association's grants may be found on the Association's website (<**www.palass.org**>). Those with deadlines in the next six months are detailed below.

Undergraduate Research Bursaries

The Palaeontological Association Undergraduate Research Bursaries are aimed at giving undergraduate students the opportunity to acquire research skills and experience that will significantly transform their academic career. The bursaries will support projects co-designed by students and their supervisor(s) that give students registered for an undergraduate degree their first experience of undertaking a palaeontological research project. The bursaries provide a stipend for the student of £287 per week for up to eight weeks. The scheme is not intended to fund students to undertake routine work for the supervisor(s) and the Association expects the supervisor(s) to provide significant personal mentoring of successful student applicants.

Applications should be made by the principal supervisor through online submission via the appropriate page on the Association's website, and will include:

- Details of the principal supervisor making the application, and other members of the supervisory team
- Details and academic track record of the named student
- An account of the project aims, methods and expected outcomes
- A project plan including details of supervision
- Ethics statement
- A referee statement in support of the named student

After completion of the work, successful **students** are required to produce a short report of the findings suitable for publication in the *Newsletter*. This report should be submitted by e-mail to <**palass@palass.org**> within eight weeks of the stated end date of the project. Successful candidates are requested to prioritize the Association's meetings and publications as media for conveying the research results.

Further details, including eligibility criteria for supervisors and students, and a full list of terms and conditions for the Undergraduate Research Bursaries scheme, can be found on the appropriate page of the Association's website. Enquiries may be made to the Secretary (e-mail <**secretary@palass.org**>).

The deadline is **1st February** each year. Successful applicants will be notified by mid-March and funds will normally be available from 1st June. A full list of awards will be announced at the AGM.

Research Grants

Awards are made to assist palaeontological research up to a maximum value of £10,000 (GBP) per award. Normally, grants must support a single research project, or a 'proof of concept' proposal with an aim of supporting future applications to national research funding bodies. Field-based projects are also eligible, but the scientific objectives and outcomes of the research must be made clear.

Applications for investigator's salary costs will only be considered in exceptional circumstances and if awarded all legal and financial liability will lie with the applicant (see: Categories of expenditure for which the Palaeontological Association does not provide support).

Other conditions

Preference is given to applications for a single purpose (rather than top-ups of other grant applications). The award is open to both amateur and professional palaeontologists, but applicants will normally have a PhD as a minimum qualification and must be members of the Association.

Preference will normally be given to candidates who have not previously won an award. Proposals must fit with the charitable aims of the Association.

Proposals will be ranked on the following criteria:

- Scientific quality of research, novelty and timeliness, likely outputs.
- Feasibility, value for money and cost effectiveness.
- Value for money and cost effectiveness.
- The scientific track record of the investigator,

At the end of the award period a final report (including receipted accounts) will be submitted for review by the Trustees or, where appropriate, external referees. This final report will also be printed in the *Newsletter*. Awardees are asked to prioritize the Association's meetings and publications as media for conveying the research results.

Applications must be submitted electronically through the PalAss website (see below for details of the Required Supporting Information), with a deadline of **1st March**. Successful applications will be reported at the May Council meeting, and funds will normally be available from 1st June. The awards will be announced at the AGM.

Categories of expenditure for which the Palaeontological Association does not provide support

Applicants are advised that the Association does not offer funding for the following costs, and hence none of these items may be included in any budget proposal submitted to the Association.

- Core funding or overheads for institutions. The Association will fund the directly-incurred costs of research on awards but, as a charity, we expect the general running costs (*e.g.* indirect costs, estate costs, support services, directly-allocated staff costs) to be provided by the host research institution. We will therefore not fund on a proportion of full economic costs (fEC) basis. Attention is drawn to paragraphs 3.31 to 3.37 of the Science and Innovation Investment Framework 2004–2014, HM Treasury (July 2004), which explains arrangements for the provision of overheads linked to charity funding to academic institutions.

- Individual items of equipment over £1,000 (GBP), sites, buildings or other capital expenditure.
- Support for the attendance at, or organization of, conferences, workshops or exhibitions.
- A shortfall resulting from a withdrawal of or deficiency in public finance.
- Student tuition fees and summer research bursaries.

Further details and a full list of terms and conditions for the Research Grant scheme can be found on the appropriate page of the Association's website. Enquiries may be made to the Secretary (<**secretary@palass.org**>).

The deadline is **1st March** each year. Successful applicants will be notified by mid May. A full list of awards will be announced at the AGM.

Grants-in-aid: meetings, workshops and short courses

The Association is happy to receive applications for grants from the organizers of scientific meetings, workshops and short courses that lie conformably with its charitable purpose, which is to promote research in palaeontology and its allied sciences. Application must be made in good time (at least nine months before the start of the event) by the scientific organizer(s) of the meeting using the online application form. Such requests will be considered by Council at the May and October Council Meetings each year. If the application is successful, we will require that the support of the Association is acknowledged, preferably with reproduction of the Association's logo, in the meeting/workshop/short course literature and other media. Enquiries may be made to the Secretary, Dr Cris Little (e-mail <**secretary@palass.org**>).

Applications should be made through online submission via the appropriate page on the Association's website, for which you will need the following information:

- Title of meeting / workshop / short course
- Date and Place proposed
- Name, position and affiliation of the organizer(s)
- Brief description (not more than ten lines) of the rationale behind the meeting / workshop / short course
- Anticipated number of attendees
- Amount requested (also whether request is for a loan or a grant)
- Other sources of funding applied for
- Specific use to which requested funds will be put

Note: If funds are requested to support one or more keynote speakers, then full details of their names, affiliations and titles of presentations should be included. The application will be strengthened if the keynote speaker agrees to submit their paper as a review article for possible publication in *Palaeontology*.

The deadlines are **1st March** and **1st September** each year.

Postgraduate Travel Fund

Financial assistance is offered to postgraduate students who are members of the Association to attend international meetings that are not directly supported by the Association through the Grants-in-aid scheme. A list of directly-sponsored meetings is given below. The funding is only intended for conferences that are explicitly scientific in nature. Enquiries can be made to the Meetings Coordinator (<**meetings@palass.org**>).

Terms and Conditions

Please read the following notes before applying:

- The award is specifically for travel.
- Applicants must be delivering a presentation (poster or oral) that falls within the scope of the Association's charitable aims.
- The maximum amount awarded will be £200 (GBP).
- Successful awards will be paid retrospectively on the submission of receipts for reasonable travel costs.
- Applications should be made online no later than two months prior to the beginning of the conference.
- The total fund and number of awards will be at the discretion of Council.
- Only one travel grant will be awarded per applicant per year, but subsequent applications can be made.
- Applications are to be made through the Association website, and should include the personal details of the applicant and his/her career stage, the title of the accepted abstract, and details of other funding obtained towards the cost of the meeting. Two letters must also be attached, in a PDF file: a letter of confirmation from the meeting convenor which states the acceptance of the applicant's abstract, and a short status-confirming letter from the applicant's supervisor.
- Funding from the Association should be acknowledged on your poster or in your presentation.

Directly-sponsored meetings (NOT eligible for the Postgraduate Travel Fund):

- Palaeontological Association Annual Meetings.
- Progressive Palaeontology.
- Lyell Meetings.
- Any other meetings that have been awarded funds to support student attendance from the Association's Grants-in-aid scheme.

No deadline: Applications are accepted throughout the year.

ASSOCIATION MEETINGS

Code of Conduct for Palaeontological Association Meetings

The Palaeontological Association was founded in 1957 and has become one of the world's leading learned societies in this field. The Association is a registered charity that promotes the study of palaeontology and its allied sciences through publication of original research and field guides, sponsorship of meetings and field excursions, provision of web resources and information, and a programme of annual awards.

The Palaeontological Association holds regular meetings and events throughout the year. The two flagship meetings are the Annual Meeting held at a different location each December, and the annual Progressive Palaeontology meeting, run by students for students with the support of the Palaeontological Association. The Association Code of Conduct relates to the behaviour of all participants and attendees at annual events.

Behavioural expectations

It is the expectation of the Palaeontological Association that meeting attendees behave in a courteous, collegial and respectful fashion to each other, volunteers, exhibitors and meeting facility staff. Attendees should respect common sense rules for professional and personal interactions, public behaviour (including behaviour in public electronic communications), common courtesy, respect for private property and respect for intellectual property of presenters. Demeaning, abusive, discriminatory, harassing, or threatening behaviour towards other attendees or towards meeting volunteers, exhibitors or facilities staff and security will not be tolerated, either in personal or electronic interactions.

Digital images and social media

Do not photograph a poster or record a talk without the author's express permission. While the default assumption is to allow open discussion of presentations on social media, attendees are expected to respect any request by an author to not disseminate the contents of their talk or poster.

63rd Annual Meeting of the Palaeontological Association
University of Valencia, Spain *15 – 21 December 2019*

The 63rd Annual Meeting of the Palaeontological Association will be held at the University of Valencia. The organizing committee is chaired by Dr Carlos Martínez Pérez. The e-mail address for all meeting-related matters is <**annualmeeting2019@palass.org**>.

Information about the meeting is provided in the coloured supplement at the back of this *Newsletter* and on the PalAss website at <**https://www.palass.org/meetings-events/annual-meeting/2019/annual-meeting-2019-valencia-spain-overview**>.

Due to high demand this year the registration for the Annual Meeting has closed early. This is regrettable but unavoidable as the meeting must adhere to fire safety regulations and lecture theatre maximum capacities. We apologize to those who are unable to attend this year and look forward to welcoming you to our Annual Meeting in 2020. The abstracts for the talks and posters will be available on the PalAss website and will be included in the conference pack at the Meeting. We look forward to seeing you in Valencia!

Abstract of Annual Address

The Annual Address will be given on Thursday 19th December.

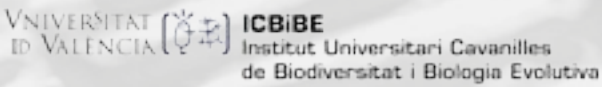
Not just skin deep: probing the secrets of fossil melanin using taphonomic experiments and analytical chemistry

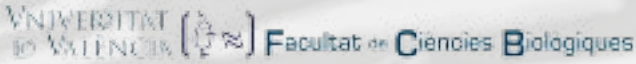
Dr Maria E. McNamara
University College Cork

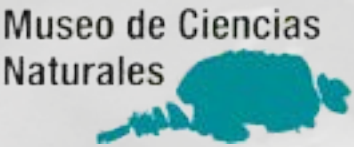
The research landscape in palaeobiology has been transformed in recent years by the recovery of evidence of melanin in diverse fossil taxa from the Carboniferous to the Pliocene. This has facilitated the first evidence-based interpretations of the original hue and/or pattern of integumentary tissues in ancient organisms, with important implications for the evolution of behaviour and ecology in key animal groups. Studies of fossil melanin have also yielded somewhat unexpected insights into the taxonomic affinities, physiology and internal anatomy of fossil animals, confirming that ancient melanin has broad applications beyond reconstructions of original colour. New advances in this developing field are underpinned by a strong analytical and multidisciplinary approach, including data from modern analogues of fossil taxa and controlled laboratory experiments investigating the taphonomy of melanin. Despite intense interest in this rapidly expanding field, certain fundamental aspects of melanin biology, preservation and evolution are incompletely understood. Here I will review progress and challenges in the study of fossil melanin, incorporating a synthesis of best practice in study design and an emerging model for melanin evolution.

Meeting support

The organizers of the Annual Meeting gratefully acknowledge the following supporters:







Student conference
run by University of Leeds students
at the Yorkshire Museum, York

Thursday 11th – Saturday 13th June

Talks, posters and social events

Geochemistry for Palaeontologists and Sampling Bias in the Fossil Record workshops

Field trip to Robin Hood's Bay

Registration and abstract submission opening soon

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Yorkshire Museum

news

Palaeontology in the News

Walking with Dinosaurs, the landmark BBC documentary series, reached the grand old age of 20 this month. First broadcast on 4th October 1999 in the UK, followed by airing in the US in April 2000, and with further worldwide release around those dates, the series has reached over 700 million people during those 20 years, according to BBC Earth. The original *Walking with Dinosaurs* series gave rise to its own 'Walking with' franchise, with beasts (covering the Cenozoic), cavemen and monsters (Paleozoic) following in the 2000s, as well other spin-offs, books, live shows and a 2013 feature film.

Back in the nineties, the release of the *Jurassic Park* film in 1993 had revolutionized how the public saw dinosaurs, and had renewed popular interest in all things palaeontological. *Walking with Dinosaurs* was the documentary for this new post-*Jurassic Park* era, using the same combination of computer-generated imagery and animated models to present dinosaurs as believable living animals.

Although the use of CGI to place convincing animals in appropriate environments was the most obvious breakthrough in *Walking with Dinosaurs*, its format – that of a 'real' wildlife documentary – is arguably the thing that made the most impact in the long term. Once the viewer had accepted the conceit of natural history film units harnessing the power of time travel they were completely immersed in a past world for 30 minutes, with no cutaways to the 'talking head' experts common to so many conventional palaeontological documentaries. For many viewers, dinosaurs were real for the first time. For those of us who cared that a broader slice of Mesozoic life was being accurately presented, the location filming in New Caledonia, Chile and New Zealand really did give the impression of a world before the flowering plants staged their global coup.

Despite the considerable palaeontological expertise that went into the programme (Michael Benton, Peter Dodson, James Farlow, Thomas R. Holtz Jr., Peter Larson and Dave Martill were all consultants) there were, inevitably, palaeontologists at the time who cried foul at some of the more speculative aspects of animal behaviour that were portrayed. Research over the last 20 years means that some of the animals would now be reconstructed differently, or placed in different genera (and let's not mention feathers). But overall, and despite the dated effects, the series stands up well to viewing in 2019, especially as a balance to a world where we seem to be in a positive feedback loop of heavily monsterized Mesozoic life in popular culture.

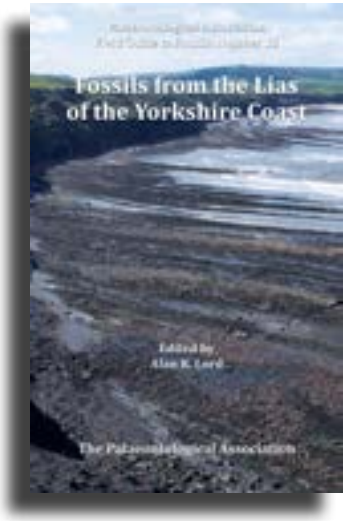
Twenty years on, when I give school talks, children are so used to seeing naturalistic CGI dinosaurs that they are often stunned when confronted with the fact that fossils are the only way that we know about non-avian dinosaurs. To them, they have always been 'real' animals, mooching around in old films and TV that even their parents grew up with. In fact, the current generation still watch the original *Walking with Dinosaurs* footage: it's just delivered as bite-sized chunks within the CBeebies series 'Andy's Dinosaur Adventures'. Its influence continues!

In recent palaeontology controversies on social media, dinosaurs have also dominated, with hooves and beaks as the points of contention. A photo of the mummified hand of 'Dakota the Dinomummy', a hadrosaur from the North Dakota State Fossil Collection, which is being prepared for a new exhibit in 2020, circulated on Twitter this month to wild responses from: 1) people who didn't realize that we already knew that hadrosaurs had hooves, 2) people annoyed that people didn't realize that

we already knew this, and 3) people who were annoyed that any nuance in the discussion of hoof morphology was being lost as the first two groups yelled at each other. For sauropod beaks, substitute the mummy photo for press coverage of research by Kayleigh Wiersma of the University of Bonn and colleagues presented at the SVP Annual Meeting in Brisbane, and replay similar arguments on social media about the novelty of the interpretation of non-skeletal features. After all that dinosaur fuss, it was lovely to see some great press coverage for a 480-million-year-old trilobite conga line from Morocco, published in *Scientific Reports* by Jean Vannier at Université de Lyon and colleagues.

Susannah Lydon
Publicity Officer

New Yorkshire field guide



We have recently published a new field guide, *Fossils from the Lias of the Yorkshire Coast*, edited by Alan Lord with contributions from numerous authors. The Lower Jurassic marine sediments seen in the cliffs and scars of the Yorkshire coast are richly fossiliferous and have been studied since the early nineteenth century. The sedimentary sequence is important for providing a window into the stratigraphy of the North Sea basins to the east and north and also because it contains the Global Boundary Stratotype Section and Point (GSSP) for the base of the Pliensbachian stage. The new field guide covers all major marine fossil groups from chronostratigraphically important ammonites to vertebrates, and terrestrial animals and plants washed into the Early Jurassic sea, reviews the early work and workers, and looks at the conservation of these important exposures. The guide

is number 15 in the Field Guides to Fossils series and is available for purchase from the online shop with a discount for members: <**https://www.palass.org/beta/eps/shop/product/fossils-from-lias-yorkshire-coast/**>.

Sally Thomas
Publicity Officer

Lapworth plaque unveiled

A plaque has been installed at the old Episcopal School in Galashiels, Scotland to commemorate the life and works of Charles Lapworth. The plaque was unveiled in May by children from the nearby St Peter's Primary school and reads "Charles Lapworth 1842–1920 Professor of Geology was headmaster here 1864–75. His Borders research led to a new understanding of the geology of southern Scotland". While living in Galashiels Lapworth carried out meticulous geological research in the Southern Uplands, particularly in Dob's Linn between Selkirk and Moffat, where he used graptolites to distinguish different strata. In 1875 he moved to Madras College in St Andrews to continue his teaching career, and began publishing the work he had done in Galashiels. He suggested the name 'Ordovician' to describe the geological period between the Cambrian and Silurian ages, and the name was adopted by the scientific community.

In 1881 Lapworth became the first Professor of Geology at the college that was to become the University of Birmingham, teaching there until he retired. You can read more about Lapworth and the Museum in *Newsletter* **91**. The Lapworth Medal is the highest honour awarded by the Palaeontological Association and is named for him.

Nick Stroud
Member and Newsletter typesetter

Photos: Nick Stroud.

The old School, now Scottish Borders Council offices.

NEWS

From our Correspondents

A Palaeontologist Abroad

Highlighting early-career researchers who have taken posts outside their home country, and the opportunities they used. This issue's palaeontologists are Ana Balcarcel, Gabriela Sobral and Pia Viglietti.

Ana Balcarcel is a Guatemalan in Switzerland, doing a PhD at the University of Zurich funded by the Swiss Science Foundation.

Q1: How did you end up in Switzerland?
I searched for PhD programmes abroad (outside of the US) and interviewed in three different European universities. I chose Switzerland for many reasons, including the quality of resources available to our lab, and the variety of methods offered to students here.

Q2: How is your position funded?
By the Swiss Science Foundation, grant funding already with the institution here and acquired by my advisor. If I need additional time to finish I will be applying for funding individually through any venues available here in Switzerland. This is a common funding format for this programme. Other programmes offer more time (longer funding, *etc*.). Some programmes offer partial time (two out of four years), with the idea of the student and advisor writing grants throughout the student's PhD. I highly recommend this programme for its resources.

Q3: What is your project about?
Domestication processes and associated effects, specifically in Artiodactyls (camelids, goats, others). We are aiming to further qualify cranial shape changes occurring between wild and domestic forms, their brain size differences, and implications (phylogenetic or order) that we can infer from the patterns we are seeing.

Q4: What surprised you most about living in Switzerland?
The peace and tranquillity of everyday life; and the shock of all shops and supermarkets being closed on Sundays.

Q5: Apart from friends and family what do you miss most about New York?
Shops being open on Sundays. Large (truly large) coffees. The diversity of people. Being able to eat out on any budget!

Ana can be reached at <**ana.balcarcel@gmail.com**>.

Gabriela Sobral is a Brazilian in Germany, working as a postdoc at the Staatliches Museum für Naturkunde Stuttgart on a DFG-funded project.

Q1: How did you end up in Germany?
I first came here accidentally. While presenting my Masters research on prolacertiforms at SVP back in 2008 (geesh, time flies!), I was suggested to continue studying it for a PhD in Berlin. I accepted the suggestion, but ended up changing the topic to braincases. After I finished my PhD, I went back to Brazil for a while, but a couple of years after that, science funding started being cut, and my project was cancelled. I thus accepted my current position.

Q2: How is your position funded?
Mine is a three-year position funded by the Deutsche Forschungsgemeinschaft (DFG). The DFG is the major research funding agency in Germany.

Q3: What is your project about?
The project was envisioned by Rainer Schoch to study a myriad of small reptiles from the upper Middle Triassic of Germany – which is similar to the project I first had in mind for my PhD. The fossils are tiny (fingernail-long) and mostly disarticulated, albeit associated. My job is to describe them and identify to which group they belong. It has been a bit of a challenge to move to post-cranial anatomy, but I'm learning a lot. So far, most of them seem to be fairly basal taxa in the lepidosaur line, which is very exciting because the early evolution of the group is very poorly known.

Q4: What surprised you most about living in Germany?
The beer! No, really, I am amazed (and grateful) how much support Germany has given to basic science. Also, the country is so rich geologically, it gives us the opportunity to tackle very diverse palaeontological questions. Outside academia, I very much enjoy the trekking and hiking culture.

Q5: Apart from friends and family what do you miss most about Brazil?
Sunshine. Since my first stay, I find the lack of sun a bit upsetting. And I don't mean winter; here sunny days rarely last until the weekend, so every opportunity I miss being inside my office is sad. I also miss air humidity – every change of season I get a nose bleed.

Gabriela tweets at @darkgabi.

Pia Viglietti is a South African in the United States of America, working as a Women in Science postdoctoral fellow at the Field Museum of Natural History in Chicago, Illinois.

Q1: How did you end up in the United States of America?

While attending the 2016 Society of Vertebrate Paleontology conference in Salt Lake City, I spoke with the Field Museum's Fossil Mammals Curator, Ken Angielczyk. Ken visits South Africa frequently as his research focuses on fossil synapsids (particularly dicynodonts) from the Karoo Basin, and he also does fieldwork in Zambia and Tanzania. With much of his research dovetailing with mine, I expressed interest in joining his lab if funding were to come available, but at the time there was none. We planned to keep in touch as such posts are administered through the Field Museum Scholarship Committee on a semi-annual basis. A year and a half passed, during which I was about to complete my Center for Excellence funded postdoctoral fellowship based at the Evolutionary Studies Institute (Wits University) in Johannesburg. Quite conveniently, Ken followed up with me concerning funding that had become available through the Field Museum. With Ken's support, I put in my application and got an amazing opportunity that has also fulfilled a dream I have had to experience living abroad.

Q2: How is your position funded?

My position is funded by the Field Museum's Women in Science Board (FMWIS). Founded in 2013, the FMWIS has become a flourishing and inclusive organization that provides many opportunities for women to engage in science and supports women at every step of their careers. Recently, they acquired funds for one postdoctoral fellowship that I am the first recipient of. Their goal is to fund one female early-career researcher for two years, but other options such as the John Caldwell Meeker postdoctoral fellowship, and fellowships through Field Museum Scholarship Committee, are also available. So, if you are interested in doing a postdoctoral fellowship at the Field Museum, keep a lookout on the Field Museum website's careers page[1] or speak to one of the curators for more information.

Q3: What is your project about?

I am collaborating with Ken on an investigation to quantify South African Permo-Triassic Karoo tetrapod communities using fair sampling and food web analytical methods. My almost ten years of fieldwork experience in the Karoo Basin will provide an unprecedented level of biological and geological data to test several hypotheses related to one of Earth's greatest biotic crises. We also plan to reconstruct communities that formed after this extinction event, when the breakdown of synapsid-dominated communities allowed the opportunity for archosaurs (and eventually dinosaurs) to diversify in the Middle and Upper Triassic.

[1] <**https://www.fieldmuseum.org/about/careers**>

Q4: What surprised you most about living in the United States?
The fact that the USA still uses cheques (rather than internet banking) for payment is quite surprising. Many people have also never heard of my name before which has resulted in some humorous pronunciations and makes ordering a Starbucks coffee nearly impossible.

Q5: Apart from friends and family what do you miss most about South Africa?
Being in a different time zone can feel quite isolating sometimes. At best I am seven hours behind South Africa (it will become an eight hours difference during daylight savings), so I miss being on the same schedule as friends and family back home. I also really miss a good "braai" as they call it in South Africa. BBQ is ubiquitous in the USA (which is delicious). But if you want to grill your own meat it is always on gas, which is just not the same as cooking over real coals. On the meat topic again, but I also miss biltong (like jerky but so much better!).

Pia tweets and instagrams at @Piazoic.

Legends of Rock

Hildegarde Howard
Forgotten woman of palaeontology

The beginnings of modern science were hostile to women's participation. The world's major academies of science were founded in the seventeenth century: The Royal Society of London (1662), the Paris Académie Royale des Sciences (1666) and the Berlin Akademie der Wissenschaften (1700). Unfortunately, women would not become members for over 300 years. Yvonne Choquet-Bruhat became the first woman to be elected to the Paris Academy of Science in 1979. Although the Royal Society was less rigid in terms of memberships than the Paris Academy of Science, it was not until 1945 that the first women were admitted as Fellows: the X-ray crystallographer Kathleen Yardley Lonsdale (1903–1971) and the biochemist and microbiologist Marjory Stephenson (1885–1948).

Figure 1. Hildegarde Howard with fossil bird from the Rancho La Brea. Image courtesy of The Natural History Museum of Los Angeles County Archives.

Despite these barriers, between 1880 and 1914, some 60 women contributed papers to Royal Society publications. Meanwhile, in the United States, geology was only a marginal subject in the curricula of early women's colleges until an intense programme was started at Bryn Mawr College in the 1890s.

Florence Bascom was one of the pioneers when geological education at universities became available to women. She received her PhD from Johns Hopkins University in 1893 by special dispensation, as women were not admitted officially until 1907; while Carlotta Joaquina Maury attended Cornell University, where she became one of the first women to receive her PhD in palaeontology in 1902.

When Hildegarde Howard began attending the Southern Branch of the University of California (now known as the University of California at Los Angeles), women were still barred from scientific societies. She was born on 3rd April 3 1901 in Washington D. C., but moved to Los Angeles at the age of five. Her main interest was journalism, until she met her first biology instructor, Miss Pirie Davidson. In 1921, Hildegarde obtained a part-time job working for Chester Stock, sorting bones from Rancho La Brea in the basement of the Los Angeles Museum of History, Science and Art (now known as the Natural History Museum of Los Angeles County). One year later, she went to Berkeley to finish her degree.

In 1928, she obtained her PhD. Her dissertation, entitled "The Avifauna of Emeryville Shellmound", became one of her most popular works, and remained as the principal reference of its kind until the appearance of the first edition of *Nomina Anatomica Avium* in 1979. She obtained a permanent position with the Museum in 1929. Although she was a curator, she did not receive that official title until 1938. Through that decade she wrote twenty-four papers on fossil birds in the American Southwest. She was promoted to the Curator of Avian Paleontology in 1944, and she would serve in that role until 1951, when she was promoted to Chief Curator of Science. She became the first woman to receive the Brewster Medal for outstanding research in ornithology in 1953.

Figure 2. Hildegarde Howard measures specimens from the Rancho La Brea Collection. Image courtesy of The Natural History Museum of Los Angeles County Archives.

Hildegarde Howard officially retired in 1961, although she continued research on fossil birds, publishing her last paper in 1992. During her extraordinary career,

Dr Howard described three families, 13 genera, 57 species and two subspecies, and remains highly regarded as one of the foremost experts in her field. She died on 28th February 1998.

Fernanda Castano
Universidad de Buenos Aires

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(Editor's note: This article was originally published on the *Letters From Gondwana* blog, at <**https://paleonerdish.wordpress.com/2019/05/01/forgotten-women-of-paleontology-hildegarde-howard/**>. Images were kindly provided by **Yolanda Bustos**, who has also written a piece about Hildegarde for the Biodiversity Heritage Library, available at <**https://blog.biodiversitylibrary.org/2019/03/hildegarde-howard.html**>.)

Behind the Scenes at the Museum

Naturkunde-Museum Bielefeld, Germany

The Naturkunde-Museum Bielefeld is a municipal natural history museum with a long history. Initially the natural history collections were part of the Museum der Stadt Bielefeld (Museum of the city of Bielefeld), established on 3rd October 1906, that encompassed a history and a nature department. These departments were separated and formed independent museums in 1930 (Keiter and Sachs 2018). The Natural History Museum moved into the Kaselowsky villa where it remained until World War II when the collections were moved to rural locations in order to protect them from Allied bombings. After the war, no permanent home could be found for almost 20 years (from 1946 to 1964). During this time, the collection, neglected and distributed among several attics, suffered heavily. A large number of specimens was lost. In 1964, the Museum was re-established with

Figure 1. Exhibition building of the Naturkunde-Museum Bielefeld, the Renaissance era Spiegelshof (source: Wikipedia).

a temporary exhibition space, and in 1977 the current administration building that also houses the geological collections was obtained. In 1986 a new permanent exhibition was opened at the Renaissance era Spiegelshof building (Figure 1).

In 2003, the Museum received the additional name "namu", which is an acronym for the German words Natur (nature), Mensch (man) and Umwelt (environment). This name also reflects the ecological idea that is depicted in the permanent exhibition.

Today the Museum houses several collections, including a biological collection (approx. 500,000 items), an archaeological collection (approx. 100,000 items, mainly Stone Age artefacts) and a geological collection (approx. 50,000 items). Part of the geological collection is the palaeontological collection, which mainly – but not exclusively – includes fossils from the wider Bielefeld region.

Palaeontological collection I – Invertebrate fossils

Invertebrate fossils form the largest part of the palaeontological collection (Keiter and Sachs 2018). Most of them, ammonites and bivalves, derive from the Lower Jurassic Herford Liassic Syncline (Althoff 1936; Büchner *et al*. 1986) and from Middle Jurassic strata, exposed in the city area. These fossils were often collected by members of the Naturwissenschaftliche Verein für Bielefeld und Umgegend (the natural science association of Bielefeld and its surroundings), an organization of local citizens that has a strong historical link to the Museum. Next to the Jurassic fossils, the collection encompasses Cretaceous invertebrates, found in the wider region, such as Early Cretaceous bivalves but also plants from the Osning Sandstone and some beautifully preserved Late Cretaceous heteromorphous ammonites (Figure 2). Notable Tertiary invertebrates include approximately 2,500 items (echinoderms, bivalves and others) from the famous Oligocene Doberg locality. Some of the Doberg specimens were donated by Dr August Oetker (founder of the world-famous Oetker food company and active member of the natural science association) in 1907 (Pankoke and Ebel 2014; Pupkulies and Keiter 2019).

Figure 2. Hyphanthoceras reussianum *(ES/kro-16014), affectionally called the "corkscrew ammonite", is one of many heteromorphous ammonite species found in the Turonian strata around Bielefeld. Size of specimen: 75 mm.*

Palaeontological collection II – Vertebrate fossils

Most vertebrate fossils derive from Mesozoic strata and were found in the Bielefeld region. As well as fish specimens (such as a three-dimensionally preserved *Lepidotes*), there are important amphibian and reptile fossils, two of which became holotypes. Witzmann *et al*. (2016) described a new species of the Late Triassic temnospondyl *Cyclotosaurus, C. buechneri*, based on a skull found within the city limits by the former Museum's director, Martin Büchner (Figure 3).

Figure 3. Holotype of Cyclotosaurus buechneri *(ES/k-36053), a temnospondyl from the Upper Triassic, Stuttgart-Formation. The skull is 33 cm long and was found over 40 years ago in Bielefeld by the Museum's director Martin Büchner.*

A partial skeleton of a Lower Jurassic plesiosaur, likewise found within the limits of Bielefeld, was established as new genus and species, *Arminisaurus schuberti*, by Sachs and Kear (2018) (Figure 4). Other notable vertebrate fossils include part of a large ichthyosaur, described as *Temnodontosaurus* sp. (Hungerbühler and Sachs 1996), footprints of Lower Cretaceous ornithopod dinosaurs from the nearby Bückeberge mountain range (*e.g.* Hornung 2015), and remnants of a Late Cretaceous elasmosaurid plesiosaur found in northern Germany (Sachs and Ladwig 2018). Highlights of the Cenozoic vertebrate collection are remains of a cave bear (another donation by August Oetker) and the skeleton of the woolly rhinoceros *Coelodonta antiquitatis* (Diedrich 2008).

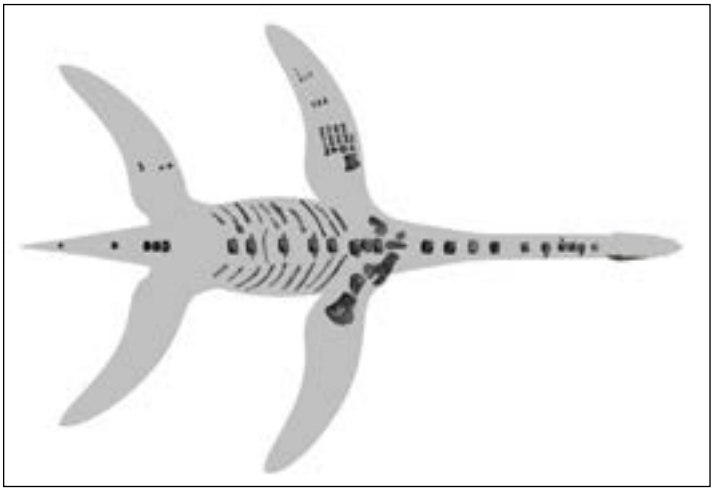

Figure 4. Overview of preserved bones from the holotype specimen of Arminisaurus schuberti *(ES/jl-36052), a new genus of plesiosaur from the Upper Pliensbachian of Bielefeld-Jöllenbeck.*

Palaeontological objects on display

The current permanent exhibition focuses on sustainable development and ecological topics, with only some fossils shown in the galleries. The fossils include a large slab containing several complete specimens of the Middle Triassic crinoid *Encrinus liliformis* as well as a number of

ammonites and selected skeletal remains of Pleistocene mammals. The 'Geostollen', an exhibition space in the Museum's basement that depicts a recreated mining tunnel, shows additional geology-related objects. Further outreach to the general public is achieved by several showcases in Bielefeld subway stations, presenting casts of selected specimens under the slogan "Verdammt lang her …" ("long long ago"). These include replicas of a *Temnodontosaurus* skull at the central train station (Figure 5) and of *Cyclotosaurus buechneri* at the Rudolf-Oetker-Halle station.

Figure 5. Showcase presenting casts of the Temnodontosaurus *skull (ES/jl-3857) in the subway of the central train station.*

Epilogue

The Naturkunde-Museum Bielefeld understands itself as the custodian of the rich natural heritage of the surrounding region. Its collection is an archive of immense value with large scientific potential. Preserving this heritage is a huge task, considering the cramped space in the historical buildings and the less-than-ideal personnel situation. Nonetheless, the 'namu' team always welcomes scientists, and will do everything possible to make specimens available for research. Feel free to visit the Museum's page at <**https://owl.museum-digital.de**>, where a good number of representative specimens are listed under "Erdgeschichtliche Sammlung".

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Find out more about the Naturkunde-Museum Bielefeld:

on the Web at <**https://namu-ev.de/**>

on Instagram at <**https://www.instagram.com/naturkundemuseumbielefeld/**>

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Extra time

Geological time, over the years, has become finely honed into the most beautiful, intricate and copiously ornamented of stratigraphic confections. A latter-day Fabergé would doubtless renounce the elaboration of mere eggs, and turn his hand to unravelling a lineage or two of trilobite or foraminifer species, or perhaps to tuning some astronomically patterned strata yet more melodiously, or even to squeeze the last drops of radio-isotopic age information out of a few sanidine or zircon crystals. These are the kinds of delicate pastimes that now routinely give geological ages to the second (or even third) decimal place of a million years, turning the metre-scale of old-style geological dating into the millimetre-rule of today. Providing an ever-more finely sculptured filigree of geological time and events, it can make one think that the future of our trade lies in burrowing away into ever more highly-resolved detail, as millions of years are disassembled into millennia, and millennia are dissected in turn into their component centuries, decades and years (and seasons). That's a trend well under way, and to be vigorously applauded – but nevertheless, it's nice to see an extra half-billion years suddenly appear, more or less out of the blue, within the span that one might sensibly equate with Earth's fossil record.

It's been slid in at the front end, of course, where the mists of time still swirl thickly – and indeed, remain mostly opaque. Quite what was going on, on Earth – not least as regards life on Earth – in the aptly named Hadean Eon is still largely a mystery. There are some wayposts along the way – one or two hammered in with a precision that would have had Fabergé clapping and cheering and throwing paper streamers into the air. The very beginning of the solar system used to be quoted at 4,567 million years, I seem to recall, until someone looked a little closer and measured 4,568.2 million years, which somehow emphasizes the point. That's the age of the first minerals (calcium–aluminium silicate inclusions) in the first rocks of our star system, after being grilled by the infant Sun, as measured by long reach of the uranium–lead decay system.

After that, it's downhill all the way. The age of the Earth itself, built by myriad collisions of those first rocks, is a little hazier, being often quoted as 4.54 billion years, built on such things as the pattern of isotopes in Archean lead veins, a billion years or so after the event. It's a hopeful monster, but fits nicely with the ages of rocks brought back from the Moon (*c.* 4.51 billion years, and so some 30 million years later). Then… well not very much, until that Archean rock record begins properly from some 3.8 billion years. The near-iconic Jack Hills zircon crystals of Australia are the most renowned members of the 4 billion year-plus club, but otherwise the cupboard is decidedly bare. That's a gap of some seven hundred million years, when all kinds of interesting things happened – like an atmosphere and hydrosphere being put into place, life starting up, that kind of thing. Rocks would for sure have been forming all over the globe – but what happened to them? That's always been a bit of a puzzle to me. Yes, it was all a long time ago – but so was the Archean, and Archean rocks are not all that uncommon. What did such terrible damage to that early crust that virtually none of it survived?

In the last decade or two, an appropriately dramatic scenario emerged that seemed to help explain this wipe-out. The *Late Heavy Bombardment* – an idea which became so in vogue that it even acquired its own acronym of LHB, joining a scrum that includes the University of Texas Longhorn Band, a Luteinizing Hormone Beta-polypeptide and the Linke-Hofmann-Busch railway

manufacturer. The LHB (geological version) emerged when dating of rocks brought back from the Moon seemed to indicate a fierce peak in meteorite bombardment sometime around 3.9 billion years ago. This then found a motive force via the Nice Model – not an aesthetic judgement, but a hypothesis developed by a meeting of astronomers in that French city: of a rearrangement of the gas giant planets of the Solar System, that created so much gravitational mayhem that asteroids were sent flying towards the orbits of the inner rocky planets.

If most of the impressive scarring on the Moon's face took place around then, the logic went, then how battered must the Earth have been, given that it was a much bigger and more *attractive* target, with its 81-fold larger gravitational field. Through impact shock, and the flash-boiling away of incipient oceans, any early Earthly life would have had to pass through a fearful mangle, if it wanted to pass on its recently improvised genetic material to some future descendants that might wish to (say) hunt brontosauri or devise Sony Playstations.

The Late Heavy Bombardment is (of course) a nice story, and over the past decade has been elaborated in all kinds of ways in shaping planetary narrative on and far beyond Earth. Why, for instance, are those two Jovian moons, Ganymede and Callisto, so different? They're roughly the same size, and have the same sort of chemical makeup, both being about half rock and half ice. But, in Ganymede these have separated out into a rock-metal core and an ice exterior that betrays all manner of ice tectonics. Callisto, meanwhile, has remained pretty much an inactive mush of mixed ice and rock with no well-defined core and none of those fancy tectonics. How so? One answer to this riddle was mooted as the Late Heavy Bombardment, in which Callisto dodged the bullets, but Ganymede took a direct hit, to shake it into a new geometry (Barr and Canup 2010).

Next-door-but-one, there's Titan's extraordinarily dense nitrogen-rich atmosphere. Where from? Well, the LHB was fingered here too, its bolides being posited to slam into Titan's ammonia-rich ice and generate the required gas, where it still remains (Sekine *et al.* 2011). On Earth, too, impact-generated melt spherule layers in Archean strata have been mooted as the tail-end of this fusillade (Goldin 2012). It's rather like with T. S. Eliot's magnificently nefarious cat – when any scandalous crime has been committed and Scotland Yard pronounce themselves baffled, why, *Macavity's not there!*

Was it really so? The warning note was sounded a few years ago, a paper was published with the provocative title "Illusory Late Heavy Bombardments" (Boehnke and Harrison 2016). Those age-dates on the moon rocks, it was argued, had been estimated by the relatively delicate argon–argon dating method; these, the authors said, could be easily re-set to give seemingly younger ages by later events such as lunar magmatism. This year Stephen Mojzsis and colleagues (Mojzsis *et al.* 2019) agreed, and added a new dynamic model of the solar system to suggest an *Early* Heavy Bombardment. The giant planets migrated, sure enough, they said – but started doing this before 4.48 billion years ago, and so just after the beginning of our star system. The peak flurry of dislodged asteroids would indeed have been brutal, but also short-lived – they suggest 30 million years – that was followed by a *monotonic* (though one suspects not monotonous) decline in impact levels throughout most of the Hadean and into the Archean.

That sets a different scenario for fledgling life on this planet, though one that needs to be thought through a little, as it seems not entirely obvious quite how much of a punch must a

meteorite pack to sterilize any promising biological start-up kit that might happen to be evolving. The extremes seem obvious. The inferred planet Theia, when it (as it seems) roared in towards its own immolation, and the gift to the Earth of the Moon, must have had a *quite* conclusive impact. A thousand-kilometre-deep magma ocean can be assumed to be terminal to life. With lesser impactors, it's not quite so clear. The infamous Cretaceous–Paleogene boundary meteorite – of which a little more anon – laid waste to a global ecosystem, but by no means to life itself, as the happy survivors were soon scrambling over themselves to fight over the spoils, perhaps even the very next day.

In between those scales of cosmic missile, there is quite a range of destruction – so how much is needed to sterilize a planet? Will boiling away the oceans do? That will likely depend in part upon how quickly the apprentice microbes began to migrate downwards – or be successfully carried downwards by whatever version of plate tectonics might have been cranking up – to set up the Earth's deep biosphere. Once life becomes established a kilometre or so below the surface[1], then a temporarily boiled-away ocean must likely only be a distant minor irritation, if that. Clearly, all kinds of ifs and buts must be built into one's ruminations. Nevertheless, a Heavy Bombardment that is Early rather than Late must have given emergent life quite a bit more elbow room on this suddenly more welcoming planet. Sensible fossil-hunting can begin a bit earlier, by that half-billion years or so.

So exactly what fossils might one seek, hammer in hand and sandwiches and flask of tea in the knapsack, as one strolls across anything that might resemble Hadean terrain? Given the time involved, the pervasive gnarling of the crust by the experimental if enigmatic tectonics of a younger and hotter Earth remains a formidable barrier to fossil-hunters, with or *sans* incoming bolides. Add to that a decided absence of conveniently fossilizeable tooth or claw or carapace in any experimental life-forms of the time, and the kind of thing one might rummage for stretches, perhaps to breaking point, any normal definition of the word 'fossil'.

How about some scraps of graphite, a few microns across, that found themselves caught up in a growing zircon crystal, itself only a tenth of a millimetre across, within a magma chamber, quite a few kilometres below ground, 4.1 billion years ago? That for sure stretches (and in my case downright boggles) both definition and imagination. Nevertheless, that was the sober, published proposal of Elizabeth Bell and colleagues a few years ago. The inference that these once were part of some living thing came largely from the graphite being curiously enriched in the light isotope of carbon, an enrichment that is usually associated with – but does not *necessarily* indicate – a biological origin.

The fine print makes for fascinating reading, nicely garnished with cautionary tales. It was no accidental discovery: the team were looking for graphite. Some of the many previous studies into these celebrated hyper-antique zircons of the Jack Hills, had noted that a whopping 4% of them had graphite within them as inclusions. A happy hunting ground for the Hadeo-palaeontologist, then? No such thing, alas. Looked at closely, almost all of this graphite was stuck within fractures within the zircons, having infiltrated into them sometime over the three billion years in which they rested in the sandstone into which they had originally been eroded. It was therefore contamination, and so had a palaeontological significance of approximately zero.

[1] Macmahon & Parnell's nice review (2018) suggests that the deep buried biosphere was present, large and thriving since at least the Archean.

Looking now closely and more suspiciously, and with a care and patience that must have felt like endless drudgery, they eventually tracked down a few graphite flakes that were wholly contained within the zircons, and so could not possibly have squeezed their way in at some later date. It was these rarities (occurring in just one-fifth of one percent of the really ancient – that is, more than 3.8 billion-year old – zircons that they trawled through) that had the suspiciously 'light' carbon isotope values that they found.

Bell and colleagues did consider non-biological ways of producing such carbon isotope values. The Fischer-Tropsch reaction is one, in which carbon monoxide and hydrogen react together to make more complex liquid hydrocarbons. This is usually a feature of human-made chemical factories (unlikely to apply to a Hadean Earth), but has been mooted to occur on asteroids. Some kind of meteoritic input might be envisaged, admitted the authors – but perhaps it's easier, they said, to think of some home-grown organic-rich shale simply being incorporated into a magma chamber, with a few cooked flecks finding their way into those slowly crystallizing zircons?

It's a possibility, and so far remains just that. A recent overview (Javaux 2019) of all the possible candidates for the earliest fossilized life on Earth mentions the Bell *et al.* hypothesis, but without much in the way of comment or enthusiasm. The raised eyebrow is evident, implying that these zircon-armoured scraps represent a *distant* possibility only. The earliest convincing sign of life noted in this most sober of reviews remains the 3.5 billion-year old stromatolites of the Pilbara region of Australia. These not only have the right kind of layering for well-behaved microbially-constructed stromatolites but – when drilled into pristine unweathered rock underground – have just been shown to be mineralized by 'nano-porous' pyrite which encloses carbon- and nitrogen-bearing strands in which the carbon has also the requisite carbon isotope signature. Game, set and match for some genuine very old fossils, is the general tone of this article (Baumgartner *et al.* in press). It's a sensible conclusion – and still leaves the best part of a billion years as fair game for fossil-hunting in a terrain that remains desperately meagre, but may now be considered more life-friendly.

We might leave a bolide-strewn temporal wasteland behind, where the error on life's origins is measured in hundreds of millions of years, to an impact setting where events have been pinned down in time with a precision that would have had Fabergé weeping with envy[2]. The report on the drilling into the Yucatan meteorite crater sets the tone with its title, on the "First Day of the Cenozoic" (Gulick *et al.* in press), but from the off it disdainfully stretches beyond the hopelessly coarse resolution of an entire day. It's the first few minutes of the Cenozoic that soon take centre stage, as an impact peak rises and collapses, with the following few tens of minutes a blizzard of accumulating melt rock particles, interacting with ocean waters as these thundered back into the space from which they had so recently and abruptly been expelled. Over the next few hours, as the waters bounce around in their brand new, beautifully circular basin, tens of metres of shock-produced debris pile up below, the whole being topped off as the originally unleashed tsunami, reflected off the adjacent coastlines that it had laid waste to, returned to its originating point over the day.

What a difference a day makes, in the vastness of geological time. Or, to make the point more precisely, what a difference half an hour makes. With the bolide travelling at in excess of 40,000

[2] Relative time here, admittedly, but still pretty impressive.

miles an hour, and an Earth diameter of some 8,000 miles, that seems roughly the difference between a hit and a near miss. The hypothetical alternative biological histories that might be mooted to explore a world in which the meteorite had missed the Earth could encompass many alternative scenarios – but none, given the quirkiness of the evolutionary tree's most bizarre twig, would likely feature a Sony Playstation or a Fabergé egg. The evolutionary process, it must be assumed, would not allow such a sense of humour.

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Spotlight on Diversity

Highlighting different experiences in palaeontology. This issue's palaeontologist, Catalina Pimiento (Swansea University), discusses "Using our large-scale vision of the world to fight climate change".

As scientists, we attend meetings and conferences around the world. A lot of us love that. Last year I was invited to a meeting in Sweden on biodiversity and ecosystem services in a changing climate. This was another meeting I wanted to go to. As such I provided the organizers with my passport details and they booked a flight and a hotel for me. I was very busy so I was relieved they were taking care of that. At the meeting, climate change was of course a main theme. We discussed mitigation and a paper (Wynes and Nicholas 2017) that had been published not long before on recommendations for individual actions: have fewer children, live car-free, avoid flying when possible, eat a plant-based diet. During the coffee breaks I talked with people. One international participant I talked with casually mentioned how long his journey had been as he had travelled by train. I immediately felt embarrassed to admit I had flown – we are discussing ways to mitigate climate change and I took a plane to do so? – I justified my travel choice by clarifying that I had come all the way from Wales. Yet, I felt like the biggest hypocrite of the Anthropocene.

The train is more expensive than the flight, the train takes longer, flying is not the biggest contributor to climate change. There are many reasons to justify flying. But the thing is, all these excuses stem from one determining issue, one that has taken us to this climate breakdown: *business as usual*. I knew that we needed to reduce our carbon emissions to mitigate global heating and I had already made changes in my personal life (although I admit I could do more), but I had not realized that I also needed to change the choices I make when it comes to my work. Flying less[1] is just one of the many things we can do as individuals to decrease our carbon emissions. But international travelling (*e.g.* to conferences, workshops, courses and fieldwork) can also be an important component of our jobs, especially for early career scientists. As such, some have published tips[2] to change our work-related travel habits. Personally, as an immigrant from South America, I cannot renounce seeing my family and stop flying altogether, but I can become more mindful about my work-related travel habits by not attending meetings that require transoceanic flights and by taking the train to conferences and workshops in Europe (even if it takes me longer and can be expensive). These choices are, however, very personal and some may find them hard to follow, *e.g.* some of us cannot afford travelling by train and some others may not even have an alternative to flying. So, what are we, as a community, doing to facilitate life-style changes for the sake of the planet?

As palaeontologists, we have a deep understanding of the consequences of global heating on biodiversity. Yet, perhaps because the time-frame of our work is in millions of years, some of us might perceive the consequences of the climate breakdown as less alarming than our fellow neontologists think. Maybe in the back of our heads, what happens in a 60- or 100-year time-frame is somewhat irrelevant. This doesn't mean that we cannot fully appreciate the catastrophic consequences of the current crisis. After all, we study mass extinctions. But perhaps we can be

[1] <**https://www.publicadministrationreview.com/2019/07/16/gnd24/**>.
[2] <**https://www.nature.com/articles/d41586-019-01652-2**>

somewhat buffered against panic because we constantly deal with extinct species, collapsing ecosystems and recovery. Is it possible that we, as a group of humans with arguably the deepest understanding of a changing climate, are not contributing enough?

I think we can do more. Since travelling internationally can be an important aspect of our careers (although it has been shown (Wynes *et al.* 2019) that reducing air travelling does not impact our productivity), we should, as a community, seek for ways to reduce the impact of it. A series of recommendations especially related to palaeontological conferences have been published (Sánchez-Villagra *et al.* 2017), which include: 1) reducing the frequency of meetings, 2) combining conferences and 3) promoting virtual participation. Other ideas come to mind, like awarding green travel grants or rewarding those who produce less emissions. These practices can be extrapolated to workshops and courses. In general, I think we can make more of an effort to send a message to society on the need for a cultural change in times of crisis. We can even go beyond flying and join civil disobedience movements (Gardner and Wordley 2019) to fight the climate breakdown. Our individual actions may not have the impact needed to change the course of the climatic crisis, but community-level actions may more effectively lead to large-scale shifts. Large-scale is in our work description as palaeontologists, so we should use that vision when it comes to fighting the climate crisis we are facing. After all, we should know more than most how enough drops of precipitation can erode a mountain range.

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>>***Future*** Meetings of Other Bodies

Conservation Paleobiology Symposium
University of Bologna, Italy *3 – 4 February 2020*

Humans have profoundly altered ecosystems on a global scale, but a lack of understanding of past conditions limits our ability to place these changes into context. This two-day symposium will bring students and researchers together and provide a venue for a lively meeting to develop themes in the rapidly expanding field of Conservation Paleobiology. We invite any researchers at any stage of their career who are using past records to help conservation efforts. The symposium is free to all, including lunch and refreshments, thanks to a generous donation and support from the Smithsonian Tropical Research Institute and University of Bologna. A small number of travel grants are available to apply for before 29th November 2019.

For more details see the website: <**https://spark.adobe.com/page/Ffnuc5r9hxepo/**>.

Association for Materials and Methods in Paleontology 13th Annual Meeting
Johnson City, Tennessee, USA *21 – 25 April 2020*

The Association for Materials and Methods in Paleontology (AMMP) would like to invite you to the 13th Annual Meeting, this time in Tennessee. Look for registration and abstract submission details coming soon to AMMP's website and social media sites.

See <**https://www.paleomethods.org/events**>.

2nd Palaeontological Virtual Congress
Virtual environment *1 – 15 May 2020*

The emergence of new applications and technologies opens a wide range of possibilities regarding new forms of communication in the scientific world. Following a successful virtual congress in 2018, the second congress is being convened, again with the purpose of spreading the most recent scientific advances in palaeontology worldwide in a fast, easy and economical way. Oral communications and posters about any palaeontological field will be presented through an online platform. The simplicity of this new format allows for low-cost registration fees and saves travel and other expenses. Consequently, this initiative aims to give international projection to the palaeontological research carried out by groups with limited economic resources, and promotes participation of palaeontologists from developing countries.

Please see the website for further details: <**http://palaeovc.uv.es/**>.

Marine Reptiles Conference 2020
The Etches Collection, Kimmeridge, UK *5 –7 May 2020*

All professionals, amateurs and enthusiasts of marine reptiles are invited to attend. The conference consists of two days of oral platform presentations, discussions and posters plus an optional conference meal on the first day and an optional field-trip to the fossiliferous Kimmeridge Bay area on the third day.

The primary focus will be on the fossil record, covering not only the marine reptiles but also the other organisms that formed part of their ecosystems. A session will also take place on modern reptiles, and we welcome abstracts from researchers studying all aspects of this field.

To register your interest please visit the website <**https://marinereptiles.org/index.php**>.

5th International Meeting of Early-stage Researchers in Palaeontology (IMERP)
Naujoji Akmenė, Lithuania *18 – 21 May 2020*

The IMERP is aimed at early-stage palaeontologists, from undergraduate students to recent post-doctoral researchers, and hopes to bring young palaeontologists together from all over the world. The meeting's character is informal and its aim is to create a friendly environment where young researchers can present their work and meet other palaeontologists from many different fields of expertise. The meeting's sessions will include presentations (oral and poster) from different fields of palaeontology, such as: vertebrate and invertebrate palaeontology, micropalaeontology, palaeobotany, taphonomy, palaeoanthropology, palaeoenvironment, palaeoclimate studies *etc*.

Keep an eye on social media for updates: Twitter @IMERP2020; Facebook @5thIMERP.

10th International Meeting of the Society of Avian Paleontology and Evolution (SAPE 2020)
University of Málaga, Spain *25 – 29 May 2020*

The meeting is open to palaeontologists, ornithologists and anyone with a general interest in bird evolution. Birds are excellent models for addressing a wide range of scientific questions, hence students and professionals of relevant research areas – functional morphology, evo-devo, conservation palaeontology and molecular systematics, among others – are encouraged to take part in the scientific sessions. Málaga is a beautiful city on the Mediterranean coast and, as one of the largest cities in Spain, has all the amenities necessary to host an international scientific meeting (*e.g.*, international airport, national railway station, huge number of hotels, and exceptional food). A two-day pre-meeting field-trip to the beautiful town of Cuenca will be organized to visit the palaeontological site of Las Hoyas and the Paleontological Museum, as well as the fantastic monuments, views and gastronomy there. Attendees of the post-meeting excursion will have the opportunity to hike along the world-renowned route of 'Caminito del Rey'. A warm invitation is extended to everyone to participate in the meeting.

For further details see the website: <**https://sape2020.com/**>.

International Conference on Modern and Fossil Dinoflagellates (DINO 12)
Palacio Congresos De Canarias, Gran Canaria, Spain *13 – 17 July 2020*

The scientific programme will be devoted to the latest developments in studies of living and fossil dinoflagellates. Dinoflagellates are one of the most important groups of planktonic and benthic marine microalgae and, as such, are of interest to both biologists and geologists. In keeping with the tradition of this conference series, the programme of the meeting (held only every 3–5 years) will consist of oral presentations and posters, supplemented by a small number of invited and keynote talks.

For more information please see <**https://dino12conference.com/**>.

2nd Crossing the Palaeontological–Ecological Gap (CPEG)
Museum für Naturkunde Berlin, Germany *6 – 9 September 2020*

A three-and-a-half-day meeting is planned without parallel sessions, with oral and poster presentations and a workshop. Besides giving a platform to scientists and work that aims to cross the gap between modern and ancient worlds, the aim is to cover all major organism groups, ecological levels and process focuses. Student prizes will be available for best presentations.
A reception event will take place in the Museum's dinosaur hall on 6th September. The Museum für Naturkunde – Leibniz Institute for Evolution and Biodiversity Science, Berlin is one of the most important research institutions worldwide in the areas of biological and geological evolution and biodiversity. with a collection of over 30 million items covering zoology, palaeontology, geology and mineralogy.

See the first circular on the website: <**https://cpeg2020.weebly.com/**>.

XV International Palynological Congress and XI International Organization of Palaeobotany Congress (XV IPC-XI IOP)
Prague, Czech Republic *12 – 19 September 2020*

This congress will celebrate 200 years of modern palaeobotany. 1820 saw the first use of binomial nomenclature for fossil plants by the Czech 'Father of Palaeobotany' Caspar Maria Sternberg, who published *Flora der Vorwelt* in that year. Palynology and palaeobotany have a long tradition in the Czech Republic with several eminent pioneers. The scientific programme in 2020 will cover all aspects of palaeo- and actuopalynology and palaeobotany and will be held at the Clarion Congress Hotel Prague. Several congress field-trips will be on offer around parts of Bohemia and Moravia. The International Organisation of Palaeobotany will financially support several postgraduate students, allowing them to participate in the conference and present their research results.

Pre-registration is available at the website: <**http://www.prague2020.cz/index.php**>.

68th Symposium of Vertebrate Palaeontology and Comparative Anatomy and the 29th Symposium of Palaeontological Preparation and Conservation (SVPCA and SPPC)
NHM, London, UK *16 – 18 September 2020*

The Symposium of Vertebrate Palaeontology and Comparative Anatomy has been held in the UK, France or Ireland every year since 1953 and is open to anyone with an interest in vertebrate palaeontology or comparative anatomy. In 2020 the conference will be held in the NHM's Flett Lecture Theatre. The morning of the 16th will include workshops on phylogenetic comparative methods and vertebrate fossil preparation; the afternoon will be a symposium on contributions of the British fossil record to palaeobiology. Regular sessions will occur on 17th and 18th September. There will be a dedicated poster session on the afternoon of the 17th, and the annual auction in the evening in aid of the Jones-Fenleigh Fund. Any presenters with no means of financial support can apply to the fund to help with attendance.

See the website for more details, at <**http://svpca.org/years/2020_london/**>.

Please help us to help you! Add your own meeting using the link on the Association's web page:
<https://www.palass.org/meetingsevents/future-meetings/add-future-meeting>.

Zoë Hughes
Natural History Museum, London

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Meeting REPORTS

4th International Meeting of Early-Stage Researchers in Palaeontology (IMERP)
Castilla-La Mancha Paleontology Museum, Cuenca, Spain *12 – 14 June 2019*

The International Meeting of Early-Stage Researchers in Palaeontology (IMERP) is a scientific meeting focused on the most recent advances in palaeontological research. In this fourth edition we believe we particularly honoured the founding principles of IMERP which are: to promote the participation of early-career researches (ECRs) in our field from all around the globe; to celebrate the meeting in regions which do not generally attract the attention of larger palaeontological meetings but whose palaeontological heritage stands out globally; to connect the visiting ECRs with the local scientific and non-scientific communities, and with culture of the region; and to generate an inclusive environment that promotes and embraces diversity, disregarding (and celebrating) differences in age, gender, culture and economic levels. The particular focus placed on ECRs meant that they played fundamental roles in both its organization and contributions to the congress, including those of the invited speakers. This, together with the international and multidisciplinary character of the IMERP, fills a gap in the available palaeontological meetings in the countries it has been celebrated in, creating new synergies between professionals and students. To guarantee the participation of early-stage researchers we offered low-cost registration fees inclusive of breakfasts, lunches, coffee breaks and accommodation during the entire meeting.

Since its creation in 2016 (Alpuente, Valencia, Spain), IMERP has gained more popularity and international relevance in the field. Lesbos (Greece) and Opole (Poland) followed in 2017 and

Participants of the 4th IMERP in Cuenca, Spain. Photo by Sergio Martínez Nebreda.

2018 as the host cities, respectively. Although a relatively young meeting, this early international trajectory has led to an increase of participants from both European and non-European countries. This edition had participants from 13 different nationalities (and three different continents): China, Czech Republic, Germany, Greece, Lithuania, Poland, Portugal, Romania, Serbia, Spain, Sweden, the UK and the USA. The total number of attendees was 105, of which 85 were ECRs, with six women keynotes and 14 organizers.

Cuenca was chosen as the host city mainly due to its tremendous palaeontological and geological heritage, with palaeontological sites of worldwide importance like the Late Cretaceous site of 'Lo Hueco' or the unique Early Cretaceous locality of Las Hoyas, which exhibits a degree of exceptional preservation of fossil tissues as few other localities in the world. Las Hoyas has been declared a Site of Cultural Interest by the regional government which grants the highest level of protection to this Konservat-Lagerstätte. The Castilla-La Mancha Paleontology Museum, the chosen venue for most of the events of the meeting, exhibits the collection of both exceptional localities and many other outcrops of the region. In order to underline how exceptional the fossils are, we organized a tour guided by some of the researchers involved in the study of the different animal and plant groups represented in these localities. Furthermore, we organized a field-trip to Las Hoyas and to Las Torcas, a karst system which is important in our understanding of the geological context of the Las Hoyas limestones and the palaeoenvironmental context of the palaeo-wetland that they represent. These two combined experiences ensured that the visiting palaeontological community had a comprehensive grasp of the relevance of the palaeontological heritage of Cuenca.

To ensure that this meeting could contribute in some way to the development of useful and transferable skills in the ECR community, we organized three different workshops taught by experts in each field. Because of the limitation of time, we wanted to focus the workshops on skills that could be learned in the timeframe that we had. The three workshops were: 'Preparing Figures for Scientific Publications', 'Social Media in Science' and 'Scientific 3D Printing'.

To generate awareness on the pressing absence of gender parity in our field, which has damaging consequences not only for the current state of our field but also affects the future of our discipline, all invited keynote talks were women researchers, renowned for being among the best researchers in their fields. The expertise of our keynotes ranged from functional morphology to stable isotope analyses, systematic palaeontology to ecological modelling and molecular palaeontology. To explore the problem of parity in science and potentially identify overlooked issues regarding women in science, and in particular in palaeontology, we organized a round-table session. This activity was a success, in particular with regard to the differences between perspectives of women in different professional positions. Thanks to our efforts, we almost achieved parity in the talks and poster contributions: 15 of the 37 talks were presented by women and 11 of the 28 posters. Furthermore, we tried to make the meeting as eco-friendly as possible. All participants used reusable cups and menus always included vegetarian and vegan options. We hope to continue this ethos at the next IMERP, to be held in Lithuania in May 2020.

This meeting was possible thanks to the support of the PalAss Grant-in-aid PA-GA201806.

Fernando Blanco (on behalf of the 4th IMERP organizing committee)
Museum für Naturkunde, Berlin

13th International Symposium of Fossil Cnidaria and Porifera
Modena, Italy *3 – 6 September 2019*

Every four years, the International Association for the Study of Fossil Cnidaria and Porifera organizes a symposium, with the most recent meeting held at the University of Modena, Italy. The 13th symposium marked a huge effort to modernize the Association, including a modification to the Association's name in order to re-establish itself within the modern community. Following a democratic vote, the Association adopted the new title of the International Fossil Coral and Reef Society (IFCRS); a new website has since been launched (<**www.IFCRS.org**>), along with a social media account (@fossil_reef), and the creation of an ECR council member position now filled by Angelina Ivkić. Inter-symposia workshops have been proposed to heighten activity between meetings.

The symposium opened with welcome messages from the chair and president Francesca Bosellini and the head of the department Alessandro Gualtieri, followed by the traditional etiquette of sounding the society's bell to open and close meetings. This year's symposium adopted the theme of 'Looking back to see ahead', with six sessions aimed at addressing this matter. These consisted of reefs and mounds in space and time; coral skeletons as tracers of biomineralization and palaeoenvironments; taxonomy and evolution; cold-water corals and buildups; palaeoecology of coral and sponge communities; and biodiversity and evolutionary patterns through time. Beside the scientific sessions, a number of pre- and post-symposium field-trips were organized, including the Devonian reefs of the Carnic Alps, Oligocene reefs and coral assemblages of eastern Lessini and Berici, and the Oligocene and Miocene reef complexes of the Salento Peninsula. These field-trips provided an excellent opportunity to soak up the Italian sunshine and share knowledge amongst the community.

The scientific sessions started with an invited plenary talk from **John Pandolfi** (The University of Queensland) who presented 'Stories from the past – prospects for the future: Whither the coral reef?', a captivating start to the symposium. **Oliver Weidlich** opened the 'reefs and mounds in space and time' session with a special dedication to the late Michaela Bernecker, an acting president of the Association who died suddenly in late 2017. Oliver offered many kind words about Michaela, along with some extraordinary moments he shared with her. After the dedication, **Nadia Santodomingo** kicked off the session with her work on reef refugia in the Coral Triangle during the past 30 million years, a fascinating piece of work supported by vast amounts of field work. She finished her talk with an open appeal to the community to come and help study the tonnes of material they have collected from the Coral Triangle. If interested in taking up Nadia's offer, she can be contacted at the Natural History Museum, London. Nadia's presentation was followed by talks on both deep time and more recent reefs, including **Angelina Ivkić**'s presentation on a comparison of modern and MIS5e reef corals in Egypt. **Markus Aretz** closed the session with his work on European and North African reefs and mounds from the Mississippian.

The second session opened on day two with a superb talk by **Katarzyna Janiszewska** on scleractinian coral biomineralization and Mg/Ca in changing oceans. Katarzyna's take-home message was that the environmental influence on skeleton formation may be taxon specific. Seven additional presentations on tracers of biomineralization and palaeoenvironments followed, with

the session being closed by **Matthias López Correa** on mineralogical and geochemical baseline screening of Antarctic carbonate secreting corals. Prior to lunch, **Ann Budd** provided an update on the scleractinian *Treatise on Invertebrate Paleontology*, along with a contribution from **Ken Johnson** on Corallosphere, a community-driven website for compiling scleractinian taxonomic information. Corallosphere is currently hosted at <**http://www.corallosphere.org/**>, although updates are planned including a potential relocation with the rejuvenation of the Society. The third session of the symposium focused on a range of talks on taxonomy and evolution. This session offered a number of diverse talks including new data on Lower Permian corals presented by **Olga Kossovaya**, and Late Ordovician stromatoporoids from North China by **Juwan Jeon**. Following this, a fascinating geo-tour was provided at the UNESCO heritage site of the Modena Cathedral and Piazza Grande by **Stefano Lugli** and **Cesare Papazzoni**.

The third day of the symposium started with a session on cold-water corals and buildups, offering not only scientific insight but also captivating images of deep-water communities. A couple of highlights included **Luke O'Reilly**'s work on the temporal variability of cold-water coral habitats, with fascinating 3D graphics from CT-scanning of coral cores, and **Mayuko Dozen**'s work on the Holocene distribution of azooxanthellate scleractinian corals, showing that old data can answer new questions. The topic then shifted to the palaeoecology of coral and sponge communities, with nine excellent talks. These included **Ken Johnson**'s talk, featuring comparison of coral growth and bioerosion between ancient and modern turbid-water reefs in the Coral Triangle, and **Thomas Stemann**'s insights into a solitary coral and large benthic foraminifera association from the Late Eocene of Jamaica. The day concluded with the congress dinner, hosted at a beautiful manor house outside the city, with plenty of laughter, delicacies and dancing to be had.

International Fossil Coral and Reef Society members. Photograph: Beatrice Fornaciari.

On the fourth and final day of the symposium, the biodiversity and evolutionary patterns through time session took place, including a number of exciting talks with novel techniques being implemented in the field. **Nussaibah Raja Schoob** presented her work on long-term biodiversity dynamics of reef-builders using a novel Bayesian framework, while **Wolfgang Kiessling** offered insights into an evolving project linking coral traits to extinction risk. **Brian Rosen** provided a summary of the data on geographically marginal reef coral assemblages from the Cenozoic, with implications of the drivers behind such assemblages. Closing the session, **Le Yao** presented his work on the composition and diversity of Mississippian coral bioconstructions.

Three well-deserved prizes were awarded for the best poster presentations to **Agostina Vertina** and co-authors on the morphological characters and ontogenetic development of deep-sea species of the genus *Caryophyllia*; **Addis Hailu** and co-authors on the palaeoecology of Pleistocene coralgal reef terraces in Ethiopia; and **Patrycja Dworczak** and co-authors on the Famennian of the Moroccan Anti-Atlas.

Many thanks to **Francesca Bosellini** and her vast team for putting together such a successful, well-organized, exciting and, above all, welcoming meeting, with such a diverse range of research. The symposium was grateful for the support by PalAss Grant-in-aid (PA-GA201807) enabling young researcher and student attendance. The next symposium will be organized by Jarosław Stolarski and team at the new European Centre for Geological Education in the heart of the Świętokrzyskie Mountains, Poland. See you all in four years!

Lewis A. Jones
Imperial College London

Francesca Bosellini and team briefing field-trip attendees on the geological history of the area: Lessini, Italy. Photograph: Beatrice Fornaciari.

67th Symposium of Vertebrate Palaeontology and Comparative Anatomy and the 28th meeting of the Symposium of Palaeontological Preparation and Conservation
Dinosaur Isle Museum, UK *10 – 13 September 2019*

This year's SVPCA/SPPC meeting was hosted by Dinosaur Isle Museum on the iconic Isle of Wight just off the south coast of England. The perfect venue for a gathering of palaeo-folk, "The Island" features some dramatic geology, with a fossil-rich sequence of sediments ranging from the Early Cretaceous to Early Oligocene, the richest dinosaur-bearing localities in Europe, and the richest Paleogene vertebrate sites in the UK; not too shabby!

Before the conference truly got under way, we assembled at Dinosaur Isle Museum to register and split into our groups for the pre-conference activities. SPPC attendees were treated to a hands-on session "Field to lab" where the full process of extracting fossils from the ground and safely transporting them to a prep lab environment was explained (complete with everyone's favourite messy activity, plaster jacketing). SVPCA attendees were treated to a field trip along the coastline exploring the Cretaceous succession between Yaverland and Culver Cliff led by **Dave Martill**, **Steve Sweetman** and **Martin Munt**. The walk was informative and a lot of fun, taking us along the beach through the Wessex and Vectis Formations to the Upper Greensand and finishing at the chalk of Culver Cliff itself. There were several lovely little finds along the way including a dinosaur rib buried in clay, and a large theropod footprint. After the field trip and workshop, we headed back to Dinosaur Isle Museum for the traditional icebreaker reception. Plenty of social lubricant and a solid selection of snacks ensured a friendly and happy crowd, with old acquaintances reuniting and new friendships blossoming over the great exhibits at the Museum, my personal favourite being the life-size Iguanodon reconstruction looming above our heads.

Theropod footprint (photo: Joe Bonsor).

The next day we assembled bright-eyed (for the most part) at the Yacht Haven in Cowes, the main town on the island, for a day filled with both SPPC and SVPCA talks. The SVPCA portion of talks were opened with a welcome from **Dave Martill**, and kicked off proper with a session focused on marine reptiles, featuring a fascinating talk by **Luke Muscutt** on the hydrodynamics of plesiosaurs, but also including a great talk from **Emma Nicholls** on the "lost" Bennett Collection of the Horniman Museum in London, one I must try and visit on my next trip to the capital. The afternoon concluded with a poster session and the chance to visit stalls from local exhibitors and palaeoartists. After dinner that evening, we were treated to **Don Henderson** speaking at the annual public Fox Lecture on "Alberta dinosaurs and the Royal Tyrell Museum of Palaeontology".

Day three kicked off nice and early with lots of coffee and biscuits and sessions on mammals and pterosaurs, my personal favourite talk being from **Matthew Wedel** on how we are still able to make completely new discoveries in human anatomy, lots of food for thought from a different point of view than I am usually exposed to. After lunch, we had further sessions on fish, and a "miscellany" session including crocodilians, Triassic archosaurs, and visualizing the topological space of phylogenetic trees. A poster session followed the talks with a strong selection from students

Icebreaker (photo: Graeme Lloyd).

as expected. Following the talks and posters, the evening featured the highly anticipated annual auction, hosted by the hilarious **Jeff Liston** with help from **Emma Nicholls** and **Dean Lomax**, who "modelled" the wares on offer. Everyone had a nice, friendly yet highly competitive time, with bids and counterbids raising a fantastic £816 for the Jones-Fenleigh fund to help pay for delegates with no institutional financial support to attend SVPCA meetings.

The very much appreciated welcome of hot coffee and pastries greeted us to the final day of talks, focusing largely on dinosaurs. We enjoyed a variety of subjects, from spinosaurs to sauropods, ceratopsians to *Cetiosaurus*, and fossil feathers to flight capability, rounded off with a final enlightening talk from **Susannah Maidment** exploring Late Cretaceous Western Interior endemism, sparking some great discussions amongst the crowd. With the talks over it was time for the awards. The runner-up for best poster was **Tom Raven** with "A revision of British Wealden Group ankylosaurs" and first prize went to **João Leite** for "Metacarpus morphospace occupation in non-avian dinosaurs", both producing clear, concise and inspiring works. An honourable mention for an excellent talk was awarded to **Robert Smyth** for "How many spinosaur taxa are there in the Kem Kem beds of Morocco?", the runner-up prize was given to **Carolina Karoullas** for "Humeral head shape: a predictor for avian flight capability?", and the well-deserved prize for best talk of the meeting was awarded to **Valentina Rossi** for her fascinating and excellently presented research on "Probing melanosome chemistry using experiments and fossils".

With formalities over, it was time for the annual dinner, held at Cowes Yacht Club, a delicious dinner enjoyed by all (any meal featuring dinosaur croutons is a winner in my book), followed by drinks in the town of Cowes for afters, a perfect way to finish a friendly, diverse and welcoming conference. I had a great time attending my first SVPCA, and I'm looking forward to seeing everyone again (and

hopefully presenting my own research) at next year's meeting, to be held at the Natural History Museum in London (16–18 September 2020). The morning of the 16th will be workshops (topics to be confirmed); the afternoon will be a symposium on contributions of the British fossil record to palaeobiology. Regular sessions will occur on the 17th and 18th. There will be a dedicated poster session on the afternoon of the 17th, with the annual auction in the evening. I hope to see you all there!

Joe Bonsor
Natural History Museum, London and University of Bath

Susie Maidment advertising the 2020 meeting (photo: Graeme Lloyd)

Yorkshire Fossil Festival
Scarborough, UK *13 – 15 September 2019*

In 2019 the Yorkshire Fossil Festival returned to its original home of Scarborough at the Rotunda Museum after being hosted in Hull the previous year. The PalAss-sponsored Festival, now in its sixth year, hosted a variety of exhibitors from across the UK to showcase a multitude of palaeontological displays and activities for fossil enthusiasts from across Yorkshire and beyond. As in previous years, the Palaeontological Association was one of the main exhibitors and this year's team consisted of **Jo Hellawell**, **Lucy McCobb**, **Susannah Lydon**, **Zoë Hughes**, **James McKay**, **Liam Herringshaw**, **Jed Atkinson**, **Cecily Nicholl** and myself. Other Festival exhibitors included regular attendees such as the Oxford University Museum of Natural History and Dinosaur Isle museum, and the universities of Leeds, Leicester and Sheffield. A rare and very well-preserved example of William Smith's map was on display at Scarborough Art Gallery to celebrate the 250th anniversary of his birth and opened to coincide with the Festival. Also opened to coincide with the Festival was an exhibition called 'Strata' by contemporary artist **Kathy Prendergast**, focusing on maps and their contours.

Friday at the Festival was the traditional "schools' day" where local school children (aged 5–11) from across Scarborough and beyond were shipped in to explore and be amazed at the palaeontological wonders laid before them. This was the perfect opportunity for PalAss to unveil the brand new 'Palaeontology Top Trumps' cards, a deck featuring a range of Cambrian arthropods, such as *Anomalocaris* and *Opabina*. The aim of the game was for children to win their opponent's cards by scoring the highest on physical features such as size or speed, or on more deadly attributes such as weapons or super senses. This simple yet enticing game proved very popular with the children; some even asked if they could buy the deck at the shops! Could palaeontological-themed card games be a future PalAss money maker?

Friday also saw the inaugural 'Jobs that Rock' careers event for older pupils, aimed at those in the

Zoë asks several festival-goers whether their created arthropods would survive the potentially deadly scenarios presented by the Wheel of Misfortune. Photo by Susannah Lydon.

final stages of their school education and hosted by the University of Hull. It was a very successful event with a careers fair and panel discussions with representatives from local consulting and geotechnical firms and of course lots of palaeontologists. As part of the day students got a guided tour of the Rotunda Museum stores with Collections Manager Jim Middleton, and a closer look at the William Smith map with Will Watts of Hidden Horizons.

On Saturday and Sunday the Festival was open to the public, who were invited to try their hand at the PalAss' various arthropod-themed activities. This included the return of the 'Wheel of Misfortune' after its extremely successful debut at the Lyme Regis Fossil Festival earlier this year. To play, festival-goers first built a chimera arthropod using an array of available body parts (I should stress that these were laminated drawings and not actual body parts), and were then encouraged to think about the lifestyles of their creation, such as whether it was a herbivore or carnivore, a swimmer or crawler *etc*. Festival-goers then went up against the wheel to see whether their creation would survive the many scenarios and natural disasters presented before them, such as earthquakes, new predators, acid rain and volcanic eruptions. The wheel also had a 'looking for love' scenario where festival-goers had to explain how they would attract a mate to pass on their genes to the next generation. This scenario was a favourite of Zoë's who enthusiastically encouraged people to come up with imaginative mating dances for their arthropod.

Through hell and high water: James battles against a leak in the PalAss tent to finish a painting. Photo by Susannah Lydon.

Festival-goers also had the opportunity to draw their creature if they wished and then have it transformed into a stunning piece of palaeoart by the committed James McKay. James was faced with a leak in the PalAss tent due to torrential rain on the Sunday but fortunately persevered by holding an umbrella in a rather unique way to protect his paintings!

On Saturday PalAss hosted a launch event for the new book *Fossils from the Lias of the Yorkshire Coast* at the Rotunda Museum. The new book is a comprehensive field guide to all major marine groups from the Lower Jurassic rocks of Yorkshire, including everything from ammonites to vertebrates, as well as the terrestrial animals and plants washed into the Early Jurassic sea, and happens to include contributions from Lucy, Zoë and Jed. The book was launched with a speech by PalAss President Charles Wellman who spoke about how the book fits in with the *Field Guides to Fossils* series. The event paid particular thanks to Martin Munt, who instigated the project and whose dedication enabled the book to come to fruition.

The Yorkshire Fossil Festival proved to be as successful as ever this year with its return to Scarborough, hosting an attendance of several thousand people over the three days. The 2020 Festival will once again be held in Scarborough and Festival organizers are seeking to build upon this success.

Jordan Bestwick
University of Leicester

Jo showcases the new PalAss book Fossils from the Lias of the Yorkshire Coast *at the launch event in the Rotunda Museum. Photo by Susannah Lydon.*

Fossils for Metal Heads
Touring Exhibition

Rock Fossils on Tour is a travelling exhibition exploring the more amusing side of zoological nomenclature. It portrays fossils that have been named in honour of rock stars, and features introductions to the fossils, rock stars and the scientists who named the fossils, together with large-scale models of the different fossilized animals (see the previous article by Luke Parry in *Newsletter* **90**). Since its beginnings in 2013, the exhibition has been on display at ten natural history museums and exhibition centres around Europe, and it is continuously expanded with more items, autographed paraphernalia, new sculptures and fresh touring anecdotes. This year *Rock Fossils* took an important jump (or stage dive) into a totally new territory for a natural history exhibition: it went on display at two huge Scandinavian heavy metal festivals. This gave a unique opportunity to bring science in general – and fossils and palaeontology in particular – out of the normal museum circuits and straight to the heart of rock fans. And it was as weird as it was successful.

The first festival we visited was Sweden Rock Festival near Sölvesborg, in southern Sweden. It is the largest metal festival in Sweden and every year it attracts more than 35,000 metal fans from all over the world. Following a massive promotion campaign launched by the festival organizers, the exhibition received its very own stage, situated just next to one of the festival main stages (The Rockklassiker stage), both of which were located inside a huge circus tent. So, in between all the scheduled concerts the lighting rig shifted focus from the main stage to the 'fossil stage'. We had used venue podiums to assemble the exhibition into different tiers, of which the topmost tier also featured a large projection area. At three scheduled occasions every day during the four-day festival, one of us (Eriksson) gave short oral presentations to the public using the projection area as well as the surrounding sculptures as visual aids. These presentations were followed by guided tours among the various sculptures, before sound and light were once again returned to whatever artist was to be performing on the main stage.

Figure 1. Mats Eriksson takes the stage between concerts and prepares to lecture for a crowd much different from the one he is used to. (Photo by Achim G. Reisdorf.)

The feedback was incredible, people really took the exhibition to heart and were commonly seen crawling all over the oversized and leather-clad trilobite named after Sid Vicious, *Arcticalymene viciousi,* while enthusiastic friends and relatives took their photos. Being used to giving lectures in quiet lecture halls to students who are there for that very reason, Eriksson personally admits that it was an unusual setting and a somewhat daunting experience to try to get the (fossil) message across to metal fans who most probably did not visit the festival first and foremost for this exhibition but for the concerts. He also notes that even if your voice is heard through the PA and is filling up an entire circus tent, it is difficult to compete with ambient noise coming from the nearest stage outside. Thus, a cautionary tale could be this: if you ever have the option, do not try to give a public address simultaneously as (British Heavy Metal band) Saxon is playing in your immediate vicinity. With all this being said, however, it was an exciting learning experience and a great fit when Sweden Rock got fossilized (that is of course besides the members of some of the headlining bands that are close to being regarded as living fossils).

Figure 2. An unusual sight at a fossil exhibition, 'dressed-up' metalheads queuing to admire fossil models. (Photo by Jesper Milàn.)

Two weeks later, the exhibition went to the Copenhell festival in Copenhagen, Denmark, which is the largest Heavy Metal festival in the country, with around 25,000 guests and four days of music. At Copenhell we got installed in the art area, sharing a large tent with different heavy metal illustrators and performance artists, which gave a really good and creative atmosphere for displaying our exhibition. The exhibition was also very well received by the Danish metal fans, who came through in a steady stream all day until late in the evening. They were full of questions and enjoyed the sculptures, taking pictures beside the models of the fossils named after their favourite rock stars. We had many amusing conversations with metal fans who in general were very interested in hearing about the fossils. One especially memorable conversation took place late in the evening with two very drunk and very happy fans who were so enthusiastic about the exhibition and simply thought that it was the best they had ever experienced at a festival, that they just could not stop hugging and praising us. This is definitely not what we were used to when showing fossils to the general public. One of these two people even proudly said that he had never set foot in a museum, but now he was

actually tempted to go and see some fossils somewhere (whether he could remember this the next day is more doubtful).

A definite highlight at Copenhell was that the Swiss folk metal band Eluveitie was playing at the festival, and as Eluveitie is one of the bands that has had a fossil named in their honour, the Jurassic sea urchin *Paracidaris eluveitie*, they readily agreed to show up in the exhibition tent for an interview with Danish television and hang out with us for a while before their performance. Chrigel Glanzmann, the founder of Eluveitie, was very fond of the sculptural reconstruction of the Eluveitie sea urchin, and thought that their fossil was the prettiest of all the models on display.

Figure 3. Chrigel Glanzmann (left), founder and singer of Eluveitie admires the model of the fossil named after his band; Paracidaris eluveitie. *(Photo by Jesper Milàn.)*

Next year *Rock Fossils on Tour* returns to the museum venues and will be on display at the Natural History Museum in Maastricht (Netherlands) January–August 2020, and continues to Museum am Schölerberg in Osnabrück (Germany) September 2020–March 2021.

The moral of this story: even a dull topic like zoological nomenclature can be made interesting and get to reach far outside the normal museum venues if presented in the right way!

Jesper Milàn
Geomuseum Faxe

Mats E. Eriksson
Lund University

Achim G. Reisdorf
Ruhr Museum

Editor's note: Interested readers should also check out Christian Klug's review of Mats' book on this subject, on page 100.

Engagement Grant REPORT

Scottish fossil workshops in rural schools

Elsa Panciroli
University of Oxford

Very few scientists visit schools in rural areas, despite many institutions carrying out fieldwork in these areas. I grew up among the rocks of the most remote parts of Scotland and have experienced first-hand how people in these communities – despite knowing their landscape intimately – are often cut off from scientific research. As a result, there is a sense of 'other' about science and scientists. This problem inspired me to create *Scottish fossil workshops in rural schools* (#ScottishFossilWorkshops). The aim was to reach schools in parts of Scotland that don't regularly receive outreach, either because of their location being distant from towns and cities, or due to low pupil numbers. This includes the area my research group works in, the Isle of Skye, where important new fossil discoveries are currently being made. I wanted to share these with pupils, along with other fossils from across the country, and describe what they tell us about the evolution of life on earth. I also wanted to encourage children to help protect their natural heritage by being responsible citizen-scientists.

"It's fab for kids here to experience visits like this! We're so far away from cities!"

Delivering the talks. Photo by Elsa Panciroli.

I carried out the workshop programme thanks to the Association's Engagement Grant (PA-OE201801). The bulk of the funds covered travel and accommodation, and the rest went into materials. This included 3D prints, and the production of an activity pack to be left with participating schools. It is a logistical challenge reaching widely-dispersed rural schools, so I set the achievable goal of delivering two two-hour workshops per day, over two weeks. Workshops comprised three components: an interactive PowerPoint presentation, a fossil-handling session and a fossil-themed game. Thankfully my partner Matt, a graphic designer, was willing to assist in producing the materials, and he joined me to deliver the workshops from 7th to 17th May 2019. We travelled over 1,400 miles, criss-crossing from the Ardnamurchan peninsula in the south-west to the Kyle of Durness in the north. Thirteen schools from the west coast and islands took part in the workshop programme, reaching over 300 pupils in total. I spoke to whole schools of children aged five to twelve years old, from the smallest and most remote classroom on the Isle of Eigg (five pupils) to the larger schools like Lochcarron (42 pupils).

The kids were overjoyed to have a palaeontologist visit, and the fossil-handling session was a massive hit. I'd selected fossil specimens from the National Museums Scotland (NMS) education collection, including plants, invertebrates and vertebrates. A 300-million-year-old shark coprolite was popular and received an inordinate amount of licking from enthusiastic pupils keen to horrify classmates and teachers. Alongside these fossils, I took a range of 3D prints including mammal and salamander jaws my colleagues and I have discovered on Skye. Each school was given a ten-times life-size 3D print of our recently published complete *Borealestes* jaw – Scotland's first-discovered Mesozoic mammal – along with a fact sheet about it, and about the process of digital printing. The fossils were selected to complement the presentation, which was split into 'What are fossils?'; 'Fossils of Scotland'; and 'Being a palaeontologist'. I tied content into the Scottish Curriculum for Excellence (CfE), particularly evolution, scientific enquiry and skills building, food chains, ecosystems, climate change, and digital technologies. This meant the content could be integrated into the wider teaching framework of the school.

The fossils for the handling sessions. Photo by Elsa Panciroli.

> *"Great balance between focused, practical, and active tasks"*
>
> *"I think they enjoyed the good mixture of listening and activity"*
> Feedback from teachers

I selected examples of Scottish fossils for the presentation that told the story of evolution and landscape change through deep time. I began with the Devonian fish of Caithness, then talked about *Aytonerpeton* (aka 'Tiny') and the work of the TW:eed project (<**http://tetrapods.org/**>), uncovering the first Carboniferous tetrapods to walk on land. I described the strange synapsid fauna from the quarries of Elgin, living in Scotland's Permian desert. Finally, we explored the rich ecosystem of Jurassic Skye. In this way we spanned seas, forests, desert and lagoon environments, following our common ancestors from the water onto land, and then the emergence of the mammal lineage.

Ask any group of children if they want to be palaeontologists, and you get enthusiastic hands-up. But people have unrealistic ideas of what the job entails. I was keen to stress the diversity of subjects, people, and skills in modern palaeontology. To this end, my presentation included diverse depictions of palaeontological practice, and a range of scientists from different ethnic and socio-economic backgrounds. We talked about skills, including less obvious ones such as art, teamwork and communication. Teachers commented that this emphasis on a wide range of skills was inclusive, and helped them to link subjects to examples of their practical applications.

The final goal of the workshops was to foster the next generation of responsible citizen scientists. Most children had already collected fossils from local sites – it's only natural that enthusiasts go fossil-hunting. One way to address the problems that arise from unregulated collecting is to educate young people to protect their local natural heritage. To meet this aim I incorporated the Scottish Fossil Code (created by Scottish Natural Heritage, SNH) into the talk, simplifying the message into four bullet points: Ask an Adult (don't collect without checking it's okay with landowners); Be Responsible (look after yourself and look after nature); Be a Good Scientist (take notes about what you find); and Tell an Expert (if you find something, show it to someone!). The children were extremely receptive to the idea that by behaving responsibly they were being like 'real' scientists, as well as looking after their environment.

Our parting gift to the teachers was to over-excite their charges with a raucous role-playing Fossilization Game. In this game, pupils were allocated animals from Jurassic Skye, and encouraged to role-play as their animal. After a few minutes, we yelled at them to all 'drop dead!' – which naturally, they loved. They then randomly drew from a bag of cards that told them if they became a fossil or not, and why. We looked at how representative the remaining fossils were of the original animal assemblage, and the 'best' ways to become a fossil. This game was a great way to discuss taphonomy, fossil bias, and the detective work of the palaeontologist.

> *"The pupils enjoyed the workshop from start to end. They loved getting questions answered. Great resources."*

To my relief, everyone loved the workshop. Feedback form responses were overwhelmingly positive – the only complaint was that they wanted more! The content was ranked by teachers as appropriate for the entire age range of the school, something I'd spent a lot of time considering and was tricky to achieve.

The final outcome of the workshops was an art competition, and from the 127 entries four winners and 18 highly commended pieces were chosen, in consultation with the Natural Sciences department at NMS. Winners received a 'Palaeontologist's Starter Kit', and the overall winner also

won a Scottish Rock Collection for their whole school to share and learn from (donated by Angus Miller of the Scottish Geodiversity Forum).

Delivering the workshops and travelling those distances was exhausting, but one of the most rewarding outreach experiences of my life. I'm indebted to PalAss for providing the Engagement Grant and donating items for the visits and prizes.I also couldn't have done this without the generous support and donations of books, leaflets and prizes from NMS, SNH, the Scottish Geodiversity Forum, the STEM team at the University of the Highlands and Islands, Dunedin Academic Press and the British Geological Survey. It would be amazing if the workshops could continue, ideally expanding to reach the rest of the Western Isles and North of Scotland. I hope in the future more scientists will consider visiting communities in the localities where they carry out research, and share with pupils and adults alike how they can participate in science and heritage protection – and perhaps become scientists themselves one day.

The four winning entries of the art competition (clockwise from top left): Violet Matheson, age 12, MacDiarmid Primary; Brodie Miller, age 10, Lochcarron Primary; Ruairidh Morison, age 5, Kyleakin Primary; Erin Cloughley-Macleod, age 8, Knockbreck Primary.

Research Grant REPORTS

A molecular palaeobiological approach to understand Onychophora terrestrialization: assessing the impact of fossils

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The origins of the animal phyla took place in the oceans in the late Neoproterozoic and early Cambrian, with subsequent colonization of land occurring independently in only a few groups later in the Palaeozoic. Onychophora, commonly known as velvet worms, represents a small invertebrate lineage of paired appendage-bearing animals that, along with arthropods and tardigrades, form the megadiverse Panarthropoda (Nielsen 2012). With fewer than 200 species described, it is the only animal phylum that is entirely terrestrial throughout life (Murienne *et al*. 2014). Onychophorans mostly inhabit the soils of tropical forests, have limited dispersal ability, and are divided into two extant families with non-overlapping geographical distributions, Peripatidae and Peripatopsidae (Oliveira *et al*. 2012). Peripatopsidae show a circumaustral distribution, being found on the southern landmasses that once surrounded Antarctica in temperate Gondwana (Chile, South Africa, Australia, New Zealand and New Guinea), and Peripatidae show a disjointed distribution, with most of the diversity in the equatorial Neotropical regions and a few species described in tropical Africa and southeast Asia (former meridional Gondwana and part of Laurasia) (Monge-Najera 1995).

Their present biogeographic distribution differs considerably from the rich diversity of onychophoran-like organisms (lobopodians) found in marine early Palaeozoic Lagerstätte, which occur globally (Ortega-Hernández 2015). The lobopodians of the early Palaeozoic constitute a polyphyletic assemblage of panarthropods, many of which have disputed systematic positions. However, recent phylogenetic studies have provided much clarity and have begun to unravel the specific affinities of these diverse fossils (Smith and Ortega-Hernández 2014; Yang *et al*. 2015, Caron and Aria 2017). Furthermore, more recent lobododian-like organisms have been described from the Herefordshire (Silurian) and Mazon Creek (Carboniferous) Lagerstätten. The most recent terrestrial fossil extends to the Carboniferous (Garwood *et al*. 2016), while the oldest unambiguous crown-group taxon is found in Burmese amber ~100 Ma (de Sena Oliveira 2016). Both of these fossil occurrences suggest a relatively late origin and terrestrialization for the group compared to the Palaeozoic origins of other major terrestrial arthropod groups.

Previous studies have dated the origin of onychophorans using node dating molecular clocks, although often only as a part of broader studies. These have retrieved ages ranging from Devonian (Rota-Stabelli *et al*. 2013; Murienne *et al*. 2014) to Carboniferous-to-Permian for the crown onychophoran divergence (Giribet *et al*. 2018). For fitting fossil species in the tree of life, we need to understand the relationship of these extinct animals with those alive today. No study has yet

specifically addressed velvet worm evolutionary history by integrating morphological data of extant and extinct taxa combined with molecular data into a single analysis under the recently developed total-evidence approaches.

Here we approach the question of Onychophora origin using this methodology that allows us to incorporate all available data in a single analysis and estimate the phylogenetic affinities and divergence times of extant and extinct taxa. We have photographed and characterized specimens from almost all the different species (~45 species) present in the rich collection of extant onychophorans at the Natural History Museum, London (NHM) (Figure 1). In order to assess the phylogenetic affinities of fossil taxa relative to the extant group, we built a morphological matrix including extant onychophoran lineages and combined with an already available matrix for most of the Palaeozoic lobopodians together with putative stem and crown group onychophoran fossils, including 46 taxa and 86 characters (Yang *et al.* 2015, Murdock *et al.* 2016). Lastly, we surveyed genetic public repositories and downloaded all onychophoran genetic data available, as well as for several outgroups, to build a molecular matrix to be combined with the morphological one. We used four molecular markers, the nuclear small ribosomal subunit (18S rRNA), fragments of both the mitochondrial 12S rRNA and 16rRNA, and a fragment of the mitochondrial cytochrome *c* oxidase subunit I, with an alignment containing 5,003 sites. Based on a previous molecular analysis and maximizing the use of monotypic genera, we selected those 37 living species that better encompass higher levels of molecular diversity of the group.

Figure 1. Plate depicting several pictures of Peripatoides novaezelandiae. *A) head dorsal, B) head ventral, C) legs and D) terminal anus.*

With the combined matrix set including morphological data from living and fossil taxa, the fossil ages and the molecular data of the living taxa, we have performed a tip-dating analysis using MrBayes. Analysis of this combined matrix of living and fossil taxa retrieved a dated timetree in congruence with current consensus, retrieving reciprocal monophyly of the families Peratopsidae and Peripatidae, as in previous phylogenetic analyses (Murienne *et al*. 2014, Giribet *et al*. 2018) (Figure 2). The affinities for some of the onychophoran stem and crown groups have not been fully resolved due to the scarcity of morphological characters. The age for the origin of crown group onychophoran, considering *Helenodora*, and hence terrestrialization of the group, is inferred to have happened at 334 Ma (306–402 Ma, 95 % highest posterior density interval), during the Carboniferous, although allowing the possibility of a Devonian origin. These ages are in general agreement with previous studies using node-dating calibration, which suggest that both families split predating the break-up of Pangaea.

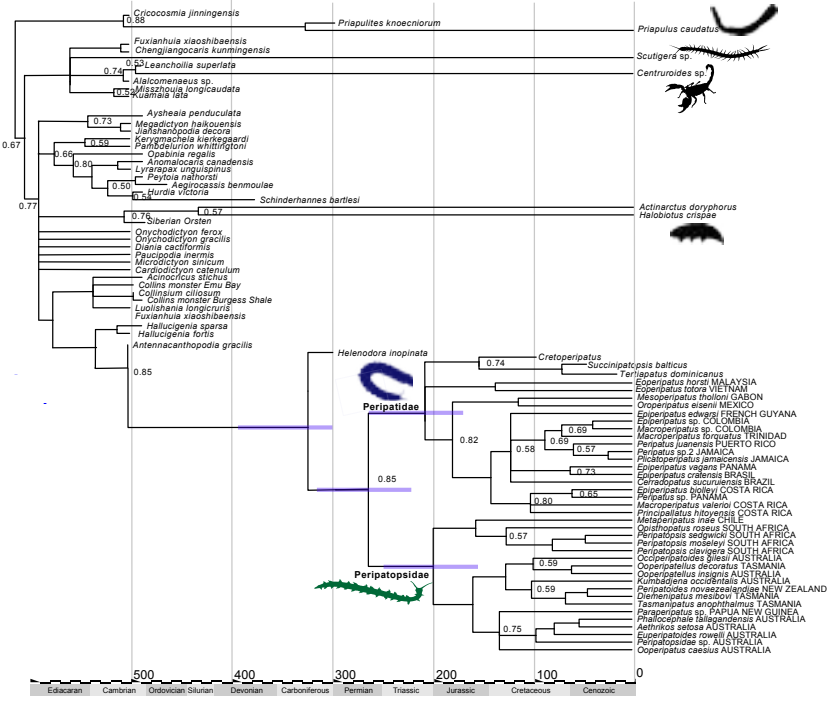

Figure 2. Tip-calibrated phylogeny including living and fossil panarthropods. The support values of those nodes with bootstrap < 0.90 are shown. Blue bars show the 95 % highest posterior density interval in main onychophoran lineages.

Ongoing research is focused on reanalysing extant samples using micro-CT scanning to obtain finer morphological details, increase the number of characters scored, and to include more recent lobopodians in the final dataset. We were granted permits by the NHM to perform tissue dissections and posterior DNA extractions of eight different species, with which we plan to do whole genome sequencing, from species that are key to resolving some of the most controversial splits in the onychophoran phylogeny.

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I gratefully acknowledge the Palaeontological Association for the Research Grant PA-RG201701 that allowed the realization of this project. I also thank Luke Parry, Richard Howard, David Legg and Davide Pisani for their ongoing collaboration in this project and to the NHM and Janet Beccaloni for helping in providing the specimens and permits.

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Pyritization of soft tissue at the Precambrian–Cambrian boundary in the southwest USA

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Pyritization of soft tissue is relatively rare in the marine fossil record, yet provides an important taphonomic window as it can preserve morphological details of soft-bodied organisms (*e.g.*, Conway Morris 1986; Wilby *et al.* 1996). Additionally, pyritization of soft tissue is indicative of specific palaeoenvironmental conditions that require low oxygen conditions, low background concentration of organic matter, and high concentration of reactive iron (*e.g.* Berner 1984; Briggs *et al.* 1996; Farrell *et al.* 2009). Reports of soft-bodied Ediacaran fossils from the southwest USA have remained scarce despite decades of study; however, in the past few years hundreds of late Ediacaran pyritized tubular fossils were discovered at two sites in Nevada (Figures 1, 2; Smith *et al.* 2016; 2017). These are the first North American examples of Ediacaran fossils preserved through pyritization, prompting a focused and systematic study of the stratigraphic intervals containing this taphonomic window across the region.

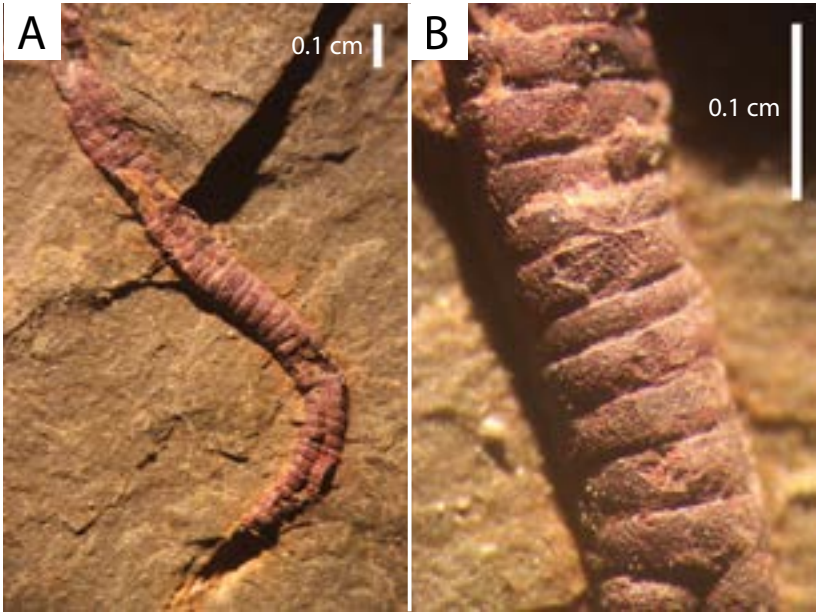

Figure 1. Pyritized fossils from the Esmeralda Member of the Deep Spring Formation at Mt. Dunfee, Nevada (Smith et al. *2016). A) Pyritized Ediacaran* Conotubus*; B) close-up of same specimen as in Figure 1A.*

The goals of this study were twofold: to place the pyritized fossils in detailed stratigraphic, sedimentological, and palaeoecological context; and to test proposed models for soft-tissue pyritization by analysing the geochemical signatures of the new fossil horizons. To achieve the first goal, dozens of localities in Nevada and California were visited to measure detailed stratigraphic

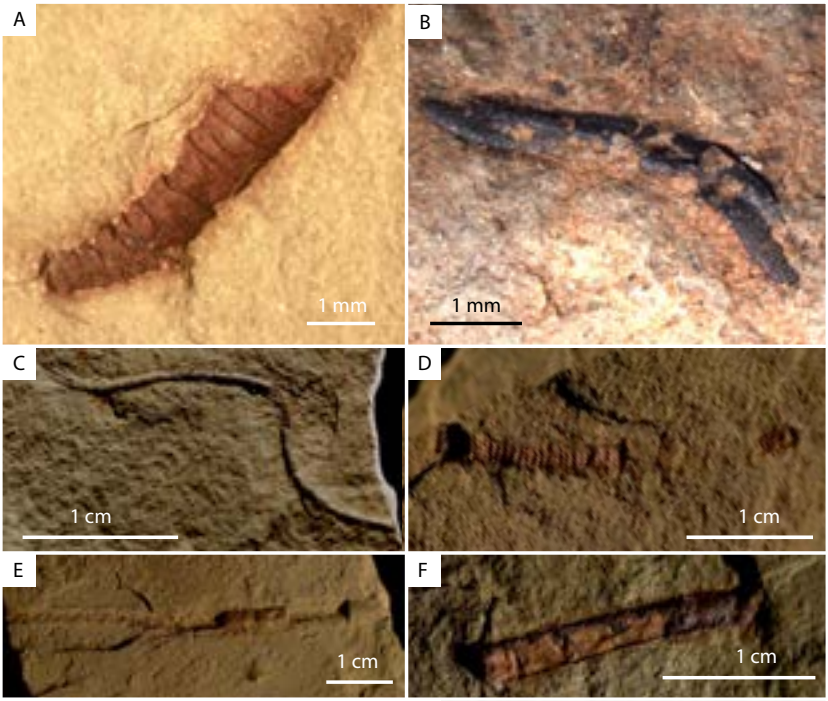

Figure 2. Assemblage of pyritized Ediacaran tubular body fossils from the lower member of the Wood Canyon Formation in the Montgomery Mountains, Nevada (Smith et al. *2017). A)* Conotubus*; B)* Corumbella*; C) enigmatic tubular fossil; D)* Gaojiashania*; E–F) smooth-walled tubular taxa.*

sections and search for additional examples of pyritized tubular fossils to understand the extent of these occurrences. To achieve the second goal, samples were collected for multi-proxy geochemical analyses to test the hypothesis that soft tissue pyritization was facilitated by the degradation of soft tissues through bacterial sulfate reduction in sediments with high concentrations of reactive iron to dissolved sulfide, and relatively low concentrations of organic carbon.

Results and research products

Fourteen composite stratigraphic sections of late Ediacaran through early Cambrian strata were measured at sites across eastern California and southwestern Nevada. At two sites, additional pyritized tubular body fossils were discovered, and a report of these fossil occurrences, along with body fossils discovered in other taphonomic modes, is in preparation. The most exceptionally preserved pyritized fossils were sent to collaborators at the University of Missouri for micro-CT analyses and detailed taxonomy. These analyses have been completed, and the results of these studies have been submitted for publication (Selly *et al.* 2019; Schiffbauer *et al.* accepted). Additionally, during fieldwork for this study, unusual macro-tubular structures preserved as pyritized casts and moulds were discovered. These structures superficially resemble the definitive pyritized Ediacaran body fossils but are an order of magnitude larger. Through careful stratigraphic, morphological and petrographic analyses, these features were identified as a new type of microbially-induced sedimentary structure (Nelson and Smith 2019). Samples from the stratigraphic

intervals preserving pyritized fossils have been collected for geochemical analyses, which are being completed at the stable isotope laboratory at Johns Hopkins University.

Research resulting from this project was presented to members of the International Ediacaran Subcommission through an international field-trip to visit some of the sites studied during spring 2018. An additional North American Paleontological Convention (NAPC) field trip to visit these sites took place in summer 2019 (Smith *et al.* 2019).

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Small Grant REPORTS

Community ecology of Cambrian deep marine scratch-circles

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The Ediacaran–Cambrian transition saw multiple significant changes in the marine biosphere and environments. The organisms characteristic of the Ediacaran – dominated by non-mineralized clades like the rangeomorphs, arboreomorphs and dickinsoniomorphs – disappeared, replaced by the more familiar organisms of Sepkoski's Cambrian Fauna, with widespread biomineralization (Erwin *et al.* 2011; Kouchinsky *et al.* 2012). This evolutionary change was accompanied by ecological change, with the development of predatory behaviours, and widespread vertical bioturbation (*e.g.* Dzik 2007). As a consequence, drastic changes were apparent in the nature of marine substrates, with the development of mixed, bioturbated layers at the sediment–water interface in shallow marine environments, replacing the widespread microbial mats characteristic of Proterozoic seafloors – known as the Cambrian Substrate Revolution, or the Agronomic Revolution (Bottjer *et al.* 2000; Dzik 2007; Seilacher and Pfluger 1994).

The precise nature of the evolutionary and ecological change across the Ediacaran–Cambrian transition, whether driven by mass extinction, or biotic turnover driven by ecosystem engineering, remains uncertain (Darroch *et al.* 2018). A key source of information in addressing this question may come from examination of deep marine environments, in which vertical bioturbation was slower to develop, with Proterozoic-style microbial matgrounds persisting perhaps as late as the early Ordovician (Buatois *et al.* 2009; Orr 2001).

The ecology of deeper marine Cambrian environments with microbial matgrounds may thus provide revealing insights into the nature of the transition interval. The Booley Bay Formation of the Avalon terrane in southeastern Ireland has been dated to the Middle Cambrian (Vanguestaine and Brück 2008), and in the type area at Booley Bay consists of a mixture of both well-sorted and poorly-sorted laterally continuous planar-bedded siltstones, interbedded with grey mudstones, coarser poorly-sorted sandstone beds, and metre-scale black mudstone horizons, interpreted as deep marine contourite-modified turbidites (MacGabhann 2007). The bedding is overturned, exposing the soles. Vertical bioturbation is limited to curved tubular undermat miner (*sensu* Seilacher 1999) *Palaeophycus* burrows, and abundant evidence exists for microbial binding in the form of microbially-induced sedimentary structures (Noffke *et al.* 2001).

No mineralized fossils have ever been reported from the Booley Bay Formation; however, at least 18 siltstone sole surfaces preserve scratch circles (Jensen *et al.* 2002; MacGabhann *et al.* 2007), arcuate to circular scratches made in the substrate by the current-forced rotation of tethered epibenthic organisms. These are up to 7.5 mm in radius, with up to eight concentric rings. Many specimens

are partial, and a central tubercle is often present. A small subset of specimens is conical in form, thought to reflect rotation around a horizontal, rather than vertical axis. The tool organisms are not represented by any body fossils, and from their morphology, we can say only that these were stalked epibenthic forms up to 7.5 mm in height, with up to at least eight protrusions along the stalk.

Spatial analysis of fossil data collected by laser scanning of surfaces from the Ediacaran of Avalonia has provided a wealth of information about Ediacaran organisms and ecosystems, including about their ecology and reproductive modes (Mitchell and Butterfield 2018; Mitchell *et al.* 2015; Mitchell *et al.* 2019). We attempted to explore the ecology of the Irish scratch circles through spatial analysis of positional data collected by image analysis of high resolution photography, as a lower cost alternative. The best-preserved surfaces were systematically photographed using a Canon EOS500D. Position and morphological data were recorded using image processing software. The recorded data were imported into R for in-depth spatial analysis, including spatial distribution described by pair correlation functions (PCF), mark correlation functions (MCF), PCF models and random labelling analysis. Spatial models fitted to the PCFs may distinguish environmental from biological causes.

For the part of the surface shown in Figure 1 (opposite page), the best-fit model for the aggregation found is a heterogeneous Poisson model which varies with the x2 co-ordinate. This strongly suggests that the aggregation is the result of systematic erosion of the bedding plane. The MCF analyses show a segregation of different sizes, and density plots of the region show that the smallest discs are found on the left and the largest on the right. This splitting of disc sizes is consistent with the differences anticipated due to bedding plane erosion, so is unlikely to be an original biological or ecological effect.

The random labelling analyses incorporate these erosional effects, so results are likely to represent the original biology or ecology of the discs. The single-ring discs do not show any significant patterns of distribution; however, the multi-ring discs do show density dependent behaviour, occupying areas of low density as a preference.

Unfortunately, combining the images for analysis of the full surfaces has proved problematic, and the development of better photographic techniques with additional data collection is required. The results are promising, however, and suggest that such additional data could provide valuable insights into deep marine Cambrian matground ecosystems.

Acknowledgements

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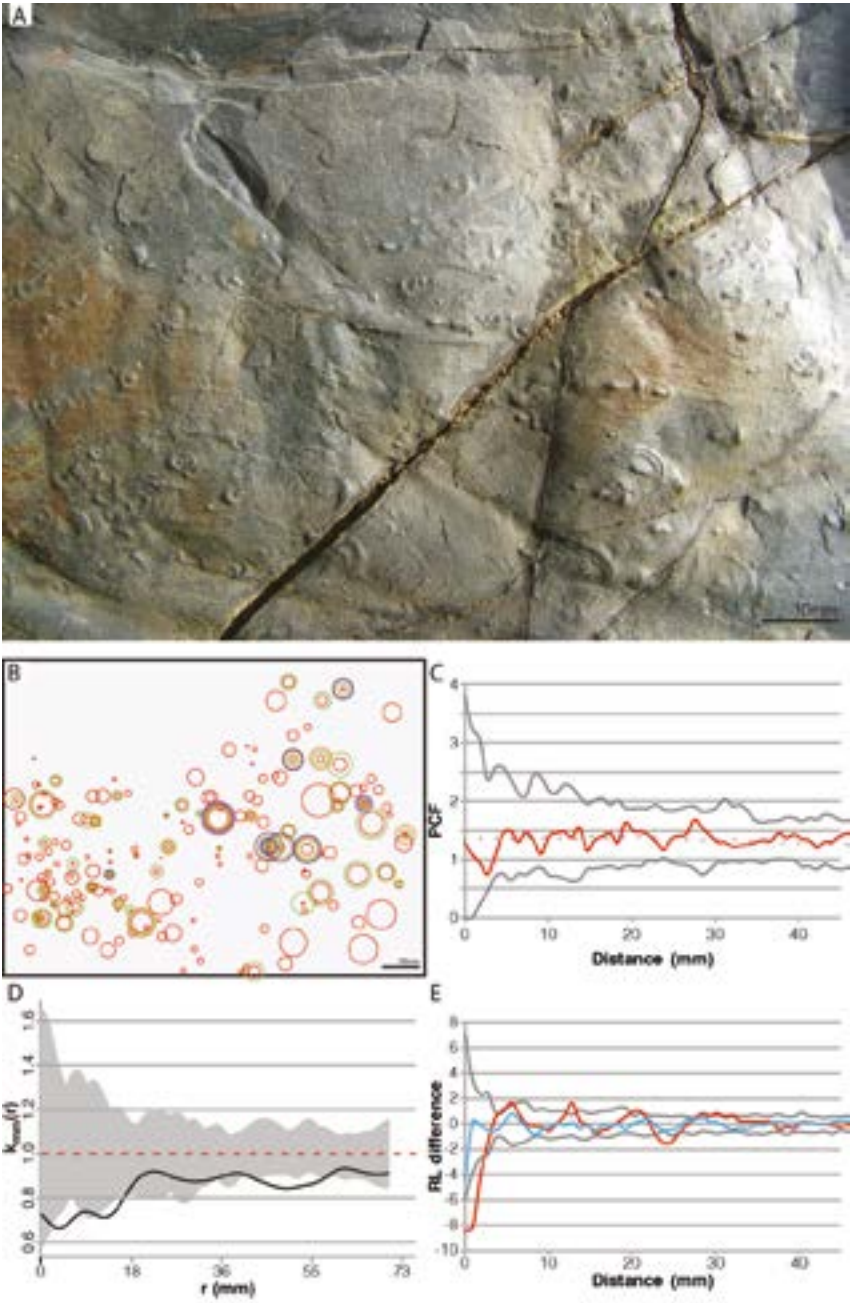
A
B
C
PCF
Distance (mm)
D
r (mm)
E
RL difference
Distance (mm)

Figure 1. (A) Image of the analysed part of the surface, showing numerous scratch circles; (B) SVG diagram of the area left, indicating the position and radius of each scratch circle ring, shown as sequentially coloured circles; (C) pair correlation function. X-axis is the inter-point distance between scratch circles; on the y-axis, PCF=1 indicates complete spatial randomness (CSR), <1 indicates segregation, and >1 indicates aggregation. Red line depicts the observed PCF; the black dotted line the best-fit heterogeneous Poisson model. The CSR hypothesis is rejected (p=0.01). Grey shaded area depicts the bounds of 99 Monte Carlo simulations of the best-fit heterogeneous Poisson model (p=0.65 where p=1 indicates perfect fit to the model and p=0 indicates no fit); (D) mark correlation function. x-axis is the inter-point distance between scratch circles; y-axis is the mark correlation function, where 1 corresponds to a lack of correlation of scratch circle radius, such that the radius is independent and identically distributed. A value of <1 corresponds to a positive dependency (in contrast to PCF) and >1 corresponds to a negative dependency. Grey shaded area depicts 99 Monte Carlo simulations. Small and medium scratch circles are more likely to be found near each other than expected by random; (E) bivariate PCF differences of random labelling analyses corresponds to the two groups of single-ring (Type 1) and muti-ring (Type 2) scratch circles. Blue line depicts PCF12– PCF11 and the red line PCF21–PCF22. Grey lines depict the bounds of 99 Monte Carlo simulations. PCF12–PCF11, found within the bounds, shows no significant deviations from CSR (p = 0.78); PCF21–PCF22 shows deviations across the boundaries (p=0.02), with significant segregation at d<5mm and at r=15mm, d=25mm. This shows single-ring (Type 1) specimens are randomly distributed, whereas multi-ring specimens show density dependent behaviour, not occurring in the areas of the joint-density pattern.

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The influence of shell calcification rate on stable oxygen isotope composition in planktonic foraminifera

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Introduction

The stable isotope composition of planktonic foraminiferal shells is frequently used for palaeoecological reconstructions (Sautter and Thunell 1991; Elderfield and Ganssen 2000; Filipsson *et al.* 2010). It has been shown, however, that the inter-specimen variation of the stable isotope composition of shells from the same location can be rather high (Ganssen *et al.* 2011), complicating the accurate reconstruction of the seawater isotopic composition based on these measurements. Part of this variation is caused by the ecology, genetics, ontogeny and seasonality of the foraminifers (Friedrich *et al.* 2012; Sadekov *et al.* 2016), but there is still some variation that is unaccounted for. This variation, probably influenced by the not yet fully understood calcification process in foraminifera (De Nooijer *et al.* 2014), introduces an error into environmental reconstructions, complicating the assessment of past ocean water conditions.

Assessing the influence of shell calcification intensity on shell isotopic composition

For this study I used material from the North Atlantic sediment trap Kiel 276. The region is characterized by a very stable carbonate system (Weinkauf *et al.* 2016), which, in combination with ambient oceanographic data, allows the elimination of other environmental effects on

the measured shell isotopic composition. The $\delta^{13}C$ measurements of the shells can further be used to normalize the $\delta^{18}O$ values for photosynthetic activity, controlling for yet another factor influencing the stable oxygen isotope composition of the shells (Spero *et al.* 1997). I used shells of *Globigerinoides ruber* (pink), *Globigerinoides ruber* (white), and *Globigerinoides elongatus* (Figure 1), which contain photosymbionts and are thus limited to the upper 50 m of the water column (Rebotim *et al.* 2017), ensuring a reliable reconstruction of the ambient environment. All specimens were weighed on a microbalance, and the shell calcification intensity was calculated as ratio between shell weight and shell size, before their shell stable isotopic composition was measured.

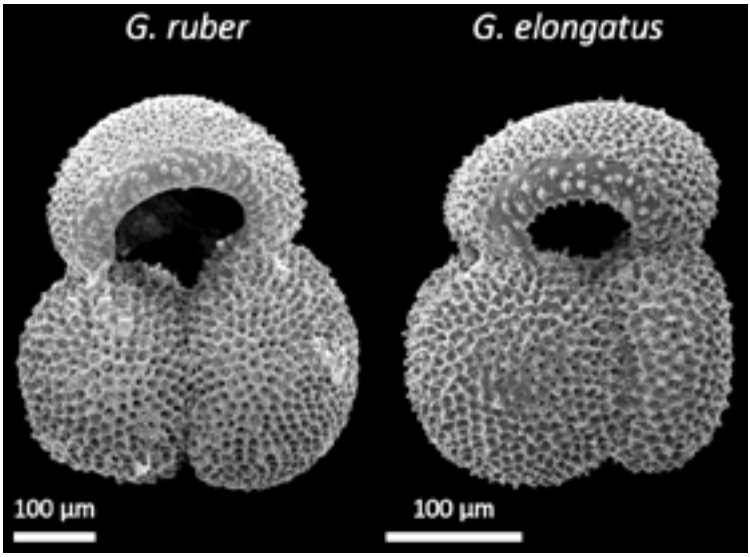

Figure 1. Scanning electron microscope images of the species of planktonic Foraminifera used for this study. G. ruber *(pink) and* G. ruber *(white) were distinguished based on the shell colour, while* G. elongatus *shows a clearly flattened terminal and penultimate chamber.*

Using a model including ambient water temperature, symbiont activity and shell calcification intensity to predict the $\delta^{18}O$ composition of the shells, I observed a significant influence of shell calcification on the stable oxygen isotopic shell composition. The effect varies between 0.2 and 0.5 ‰ and explains between 3 and 10 % of the observed $\delta^{18}O$ variation of the shells. While other environmental factors have a predictably larger effect on the stable oxygen composition of foraminiferal shells, the effect of isotope fractionation as influenced by shell calcification intensity is noteworthy and can bias palaeoenvironmental reconstructions that do not take this factor into account. The results of the study, which will be of interest to geochemists and palaeoclimatologists, are currently being prepared for publication (Weinkauf *et al.* in prep.).

Conclusion

Using planktonic foraminiferal shells from a North Atlantic sediment trap, I demonstrated that there is a biasing effect of shell calcification rate on the stable isotope composition of planktonic foraminiferal shells. This factor needs to be taken into account for high-precision palaeoenvironmental reconstructions.

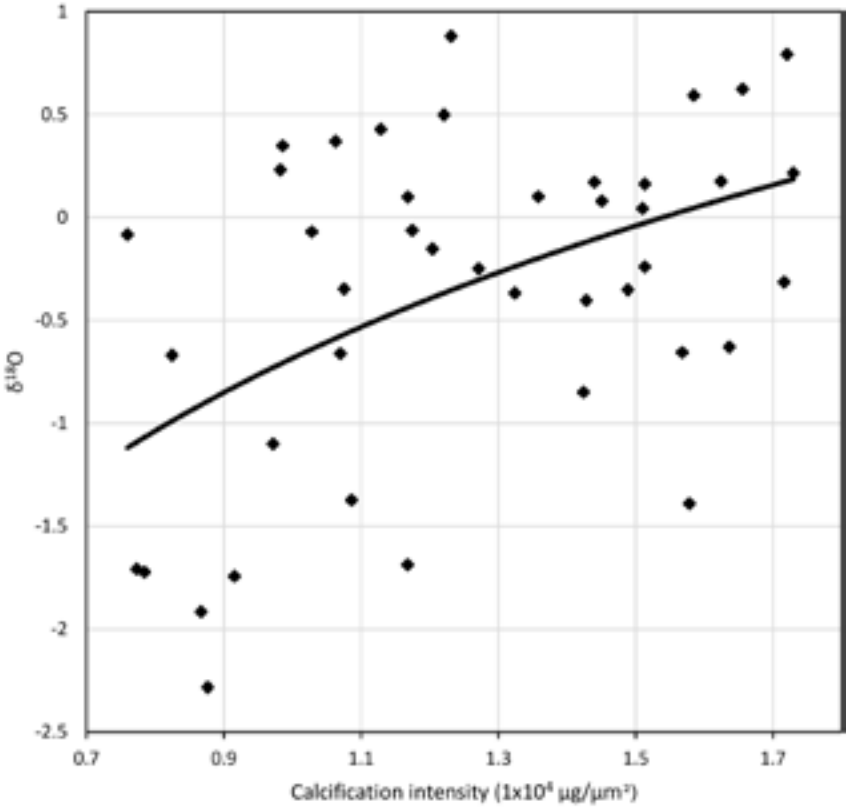

Figure 2. Preliminary results from G. ruber *(white), showing the connection between shell calcification intensity and shell stable oxygen isotope composition.*

Acknowledgements

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Undergraduate Bursary REPORTS

The evolution of alkenone-producing coccolithophore algae

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My project focused on a group of marine planktonic calcifying algae: the coccolithophores. Specifically, I generated data to document changes in coccolithophore cell sizes across a key interval in their Cenozoic history - the early Eocene origin of the reticulofenestrid coccolithophores. This group of coccolithophores, which includes the modern and famous (as far as coccolithophores go!) *Emiliania huxleyi*, are very important for studies of Cenozoic climate change. First, they are one of the dominant groups of calcifying microplankton of the past 50 million years, dominating coccolithophore assemblages, and playing a significant role at the base of the open ocean food chain (Rost and Riebesell 2004). Part of their success might be to do with a particular fatty compound (or lipid) type, called alkenones, that only this group of coccolithophores produce (Brassell 2014). Alkenones seem to give reticulofenestrids an evolutionary advantage over other groups but are also often preserved in marine and ocean sediments, especially in the Neogene. By studying the chemistry of alkenone compounds, organic geochemists have developed ways of estimating both sea surface temperatures (U^k_{37}; dependent on the degree of saturation of the alkenones) (Prahl *et al.* 1998) and the concentration of carbon dioxide in the atmosphere, based on the carbon isotope composition of alkenones (Zhang *et al.* 2013). These 'proxy' measures rely on an understanding of how both the physiology and growth environment impacts the chemistry of these single-celled algae. In particular, the size of the algal cell influences how easily they uptake the carbon necessary for photosynthesis: it's easier for smaller cells (Bolton and Stoll 2013). As the alkenone-based estimates of carbon dioxide rely on the effect of this carbon limitation on the carbon isotopic composition of the cells, it's really important to have good estimates of cell size when using this proxy.

Current alkenone-based reconstructions of ancient CO_2 concentrations extend back to 44 Ma, within the middle Eocene (Zhang *et al.* 2013). We have no alkenone-based estimates of CO_2 older than this, mainly because of the very low abundance or absence of alkenone biomarkers in most marine cores from the early Cenozoic. Recent studies of early Eocene sediment cores from the Rockall Trough, to the west of Ireland, have however revealed the presence of diverse and abundant organic biomarkers – including high concentrations of haptophyte-derived alkenones – along with well-preserved coccoliths and other calcareous nannofossils back into the early Eocene (Dunkley Jones pers. comm., see Figure 1). These new occurrences of alkenones extend back to ~51 Ma, critically spanning the interval of peak Cenozoic warmth, known as the Early Eocene Climatic Optimum (EECO). My project worked as part of a team that are currently trying to generate new records of

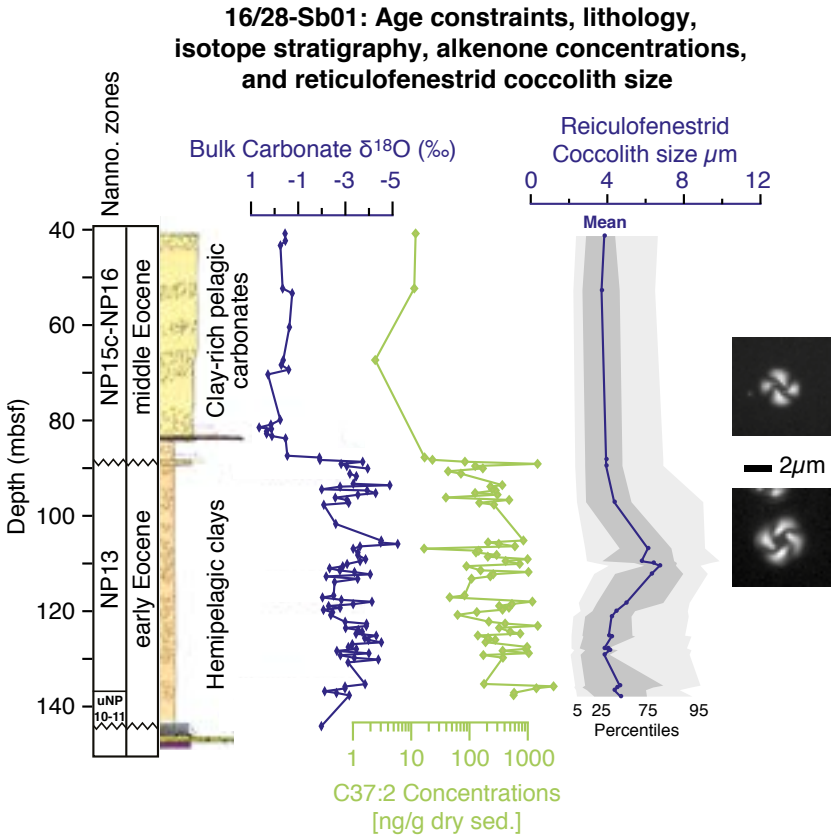

Figure 1. Biostratigraphy and sedimentary logs for 16/28-Sb01 with coccolith-carbonate oxygen isotope values (purple), concentrations of haptophyte-produced alkenones (green), and reticulofenestrid coccolith size (right; mean values plus 5, 25, 75 and 95 percentiles).

early Eocene CO_2 based on the alkenone-pCO_2 proxy to fill major gaps in our knowledge of Cenozoic climate evolution, including quantifying the relationship between temperature and CO_2 during peak Cenozoic warmth. Alongside the analysis of alkenone biomarker carbon isotope compositions, a full assessment of the proxy requires an estimation of cell-size of the reticulofenestrid coccolithphores that produced these alkenones. Further, initial data from the core, which spans intervals extending back to ~53 Ma, indicates that alkenone biomarkers are only present in the core after the first appearance of reticulofenestrid coccolithophores at ~52 Ma; potentially a major finding that ties the evolution of this group to the first use of alkenone lipids for energy storage.

My study produced a detailed record of reticulofenestrid size changes through the early and middle Eocene of core Rockall core (Figure 1). As well as confirming the absence of reticulofenestrids before ~52 Ma at this site, the data also show a marked increase in reticulofenestrid cell size (Figure 2), coinciding with conditions of peak Cenozoic warmth, and we think peak-CO_2 conditions, during

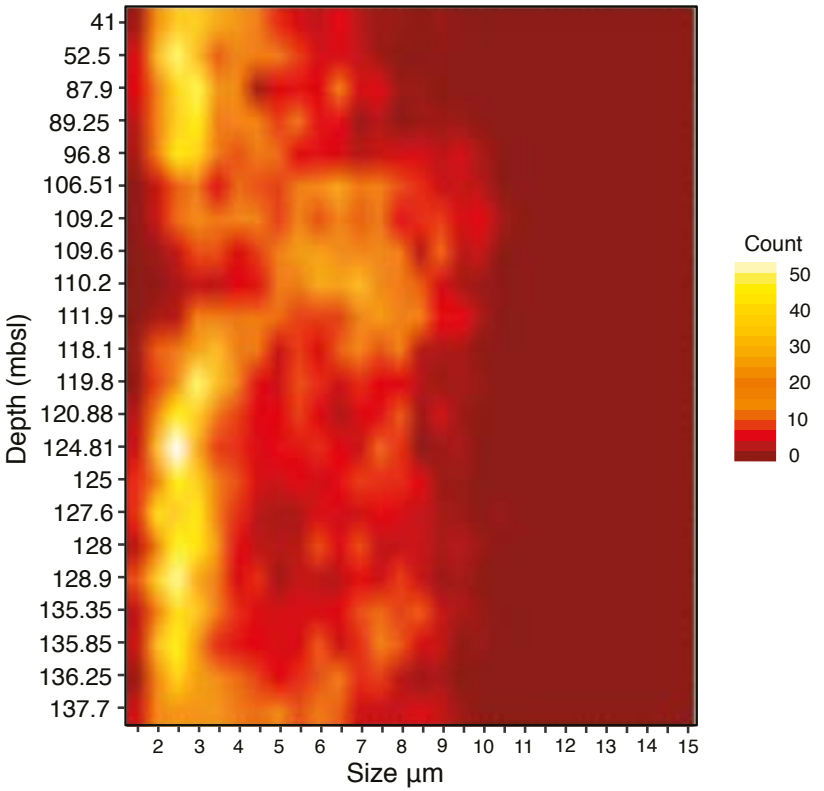

Figure 2. Detailed reticulofenestrid coccolith size distributions with depth in core 16/28-sbo01. Measurements on 200 specimens per sample; heat map colours show frequency distributions per half micron size categories.

the EECO. Cell size then declines out of the EECO and remains consistent into the middle Eocene. These results are the first indication that as well as changing the isotopic composition of alkenone biomarkers, over long timescales, high levels of atmospheric CO_2 might cause an adaptive increase in coccolithophore cell-size, through the enhanced availability of carbon for photosynthesis and calcification. This study will be included in future publications documenting the maximum possible age for the application of the important alkenone pCO_2 proxy and important new records of early Eocene atmospheric CO_2 concentrations.

Acknowledgements

I am grateful to my supervisor Tom Dunkley Jones for his help with this project, as well as the Palaeontological Association for Undergraduate Research Bursary PA-UB201805.

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Analysing an exceptionally-preserved Silurian asterozoan

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Introduction

The Asterozoa are a subphylum of the Echinodermata divided into two classes: Ophiuroidea (brittle-stars) and Asteroidea (starfish). This project is an investigation of a new asterozoan specimen from the Silurian Herefordshire Lagerstätte (Briggs *et al*. 1996) that preserves soft-tissues including tube-feet and internal structures; such occurrences are extremely rare in the fossil record, and hence of great potential significance. The only other reported lower Palaeozoic asterozoan preserving similar anatomical detail is *Bdellacoma*, from the same deposit (Sutton *et al*. 2005).

Materials and methods

The part and counterpart of the 1 cm long fossil were serially ground and digitally photographed at 20 µm intervals, forming a dataset of 715 images that were reconstructed into a 3D 'virtual fossil' using the SPIERS software suite (Sutton *et al*. 2012). Details of the method, which involves careful manual image-preparation, are given by Sutton *et al*. (2014). Preparation work was concentrated on the central arm and disc and the soft-tissues, in order to obtain data on the organism's plating structure for taxonomic identification and because of the rarity of soft-tissue preservation. Following reconstruction, the model's morphology and plating structure were compared to stratigraphically and palaeogeographically proximate taxa to determine taxonomic affinities.

Fossil reconstruction

Body morphology

The specimen is preserved with little taphonomic distortion, although some compression is evident in the tube feet (Figure 1A). One arm (Figure 1E) is folded distally; while the axis of folding is compatible with the apparent compressive direction, it affects only a portion of this one arm, and is hence interpreted as *in vivo* mobility/flexibility, rather than as a taphonomic artefact. The asterozoan has a central disc from which five arms protrude, each of approximately 60 % of the disc's diameter in length (Figure 1A). Arms taper at a constant rate outside of the disc to points

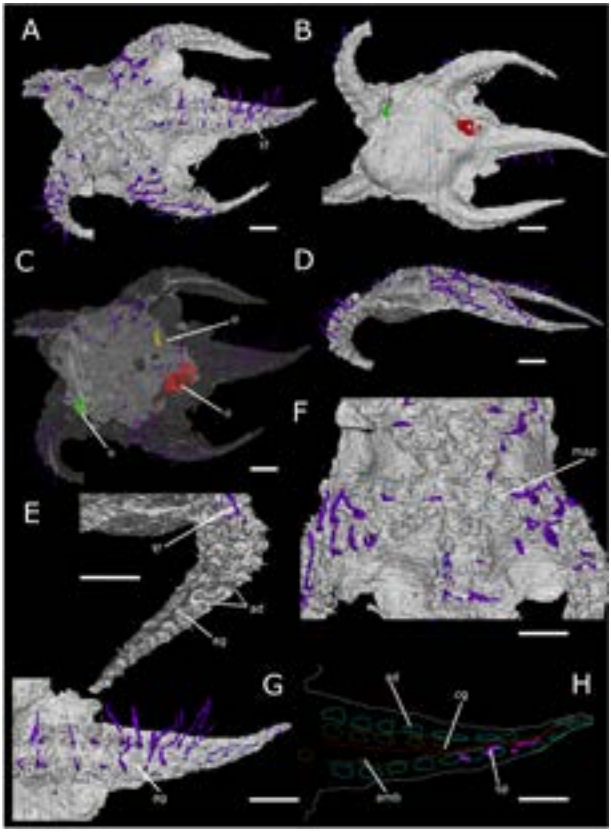

Figure 1. Protaster? *sp. in oral view (A), aboral view (B) and internal view (C); D lateral view; E folded arm with tube feet not seen along the folded section; F closer view of oral plates; G closer view of one arm's plating and spines; H an interpretation of Figure 1G. Abbreviations: ad, adambulacral plates; ag, ambulacral groove; amb; ambulacral plates (identified by the presence of bays); cg, central groove; map, madreporite; o, internal organ; sp, spine; tf, tubefoot. All scale bars are 1 mm.*

and have a near constant width/height ratio of approximately 3:1. Ambulacral grooves run the length of each arm (Figures 1E, F). Arms are well differentiated from the disc, divided by prominent interradial side shields. The disc is slightly domed ventrally with a 3:10 depth:diameter ratio (Figures 1C, D) and has a suspected madreporite on the oral side (Figure 1F). No anus is visible on the aboral side (Figure 1B).

Plating structures

Plates are thin and lack visible boundaries in the interradial disc and on the aboral side (Figures 1A,B). Plates are thicker on the mouth and arms; roughly three times thicker for ambulacral plates, ten times thicker for adambulacral plates and thirty times thicker around the mouth. Ambulacral ossicles occur at the base of the ambulacral groove. They are biserially arranged, with columns offset by ~25 % of ossicle length, and separated by a shallow central groove (Figures 1F,G).

Ambulacral ossicles are un-ridged, have a 2:3 width:length ratio, and contain a small medial embayment from which the tube feet appear to originate. Adambulacral ossicles are similarly arranged; they are blocky and sub-rectangular, with a 5:12 width:length ratio. Adambulacrals bear short paired spines on their distal edges; these are distally directed at ~20 degrees to the adambulacral long-axis. There are approximately 18 pairs of ambulacral and adambulacral plates per arm; where preservation is good, each pair is associated with a pair of tube-feet, and hence we infer that the organism possessed ~18 pairs of tube feet per arm.

Soft tissue

Tube feet are present from the mouth to the tips of the arms (Figures 1A,C,D,G,H). These display little morphology, and lack suckers or basal expansions. They are longest near the centre of the arm; distally they shorten to ~25 % length near the arm-tips, and proximally they shorten to ~50 % length towards the mouth. Internally, three structures are present (Figures 1C,D). They are sac-like and are located interradially. They are unconnected to the mouth, and it is unclear what organ they represent, or whether they are pentamerally symmetrical repetitions of the same organ.

Classification

The new asterozoan is most closely comparable with members of the Protasteridae, as demonstrated by its prominent side shields – well separated from its arms – which lack a well-developed margin (Durham *et al*. 1966; Hunter *et al*. 2016; Shackleton 2005). In addition, laterals contain short spines and ambulacrals slightly alternate; both characters are often displayed in protasterids. The closest match to a known genus is *Protaster*, the type-species of which is *Protaster sedgwickii* (Spencer 1934), which also occurs in the Avalonian Silurian. The current material is similar to *P. sedgwickii* in overall shape, and in its weak interradial plating on the disc, similarly shaped laterals, and flat, embayed ambulacrals. However, the lack of pronounced aboral plates prevents specific identification with *P. sedgwickii*. The new specimen is unlikely to be a member of any other known genus of this family, by comparison to papers cited in the *Treatise on Invertebrate Paleontology* (Durham *et al*. 1966). Nonetheless, in view of the difficulties in determining plating structure in the current material, I also refrain from a firm generic placement within *Protaster*; the new material is treated under open nomenclature as *Protaster*? sp.

Phylogenetic significance

The protasterids are traditionally considered a 'protophiuroid' family; they may belong in the ophiuroid stem-group, or potentially in the stem-group of the asterozoans as a whole. This position reflected in the mix of characters from both classes shown in *Protaster*? sp.; it has arms separated from the disc and an orally located madreporite like an ophiuroid but lacks the long arms with enclosed ambulacral grooves that are diagnostic in modern species. The precise position of the family is part of the broader problem of Palaeozoic asterozoan phylogeny (see *e.g.* Mah and Blake 2012). Nonetheless, the discovery of simple (non-suckered) tube-feet in a 'protophiuroid' provides confirmatory evidence that suckers are synapomorphy developed within the crown-group Asteroidea, rather than a plesiomorphic condition within Asterozoa as a whole.

Further work

The next stage of this project would be to undertake a full phylogenetic coding of the organism as part of a broader cladistic study into the timing and nature of the ophiuroid/asteroid split,

and hence to determine its phylogenetic position more precisely. Further investigation into the Herefordshire fauna may also provide new specimens with more data, or indeed specimens of other Silurian asterozoans with similar soft-tissue detail.

Acknowledgments

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Biotic disturbance in the latest Eocene – impact events and climate cooling

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Introduction

The Eocene–Oligocene Transition (EOT), ~34 Ma, is the most significant climatic shift in the Cenozoic (Zachos *et al.* 2001). Over ~500,000 years, long-term late Eocene cooling resulted in significant continental ice sheet growth, in turn causing a major, ~60 m, eustatic sea level fall. The EOT completes the transition from an early Paleogene greenhouse climate with high CO_2 levels (>1,000 parts per million/ppm) and no continental ice to a Neogene icehouse climate with lower atmospheric CO_2 levels (<500 ppm) and substantial polar ice caps. Little is known about the magnitude and timescales of late Eocene climate cooling preceding the EOT due to a lack of high-quality marine sediment records. A highly expanded and seemingly continuous industry core, recovered from Mossy Grove in Jackson, Mississippi, USA, spanning ~33–37 Ma, may provide new insights. An existing (unpublished) high-resolution fine fraction, <20 µm, carbonate stable isotope record already exists for the Mossy Grove core (De Lira Mota pers. comm.). In this PalAss-funded project, we generated new benthic foraminiferal stable isotope and assemblage records from the Mossy Grove core to better constrain the nature of the EOT. We also used the relative abundance of planktic foraminifera to test for evidence of sea level change through the EOT.

Methods

Sixty-two marine sediment samples spanning 215–358 ft within the Mossy Grove core were processed for this project. First, the sample was weighed and dried in an oven at 40°C to remove moisture and calculate a dry bulk sediment weight. After ensuring that the sample was dry, it was washed down with deionised water over a 20 µm sieve. The fine fraction of each sample (<20 µm) was stored for future nannofossil analysis. The >20 µm fraction was dried and weighed. The sample was then dry-sieved and the 250–300 µm fraction was picked under a binocular light microscope for select species of benthic foraminifera (*Uvigerina* and *Cibicides*) and all planktic foraminifera. Twenty-six samples had sufficient (>2) benthic foraminifera specimens for stable isotope analyses. The oxygen and carbon stable isotope data collection was conducted at the Natural Environment Research Council Isotope Geosciences Laboratory facility (NIGL).

Preliminary results and interpretation

Across the EOT, bulk sediment $\delta^{18}O$ values increase by ~1 ‰, similar to the composite benthic foraminiferal record of Zachos *et al.* (2008; Figure 1). Benthic foraminiferal assemblages show a shift from *Cibicides*-dominated to *Uvigerina*-dominated assemblages, interpreted as a shift in the concentration of O_2 and/or organic matter flux (food availability) at the seafloor, between epifaunal *Cibicides* (indicating higher oxygen concentration and/or less food) to the infaunal *Uvigerina* (indicating lower oxygen concentration and/or more food) (*e.g.*, Jorissen *et al.* 1995). Examples of *Cibicides* and *Uvigerina* observed during this project in the Mossy Grove core are shown in Figure 2. There is also a marked disappearance of planktic foraminifera across the EOT, consistent with a significant sea level fall. Interestingly, benthic foraminiferal $\delta^{18}O$ values do not show the expected

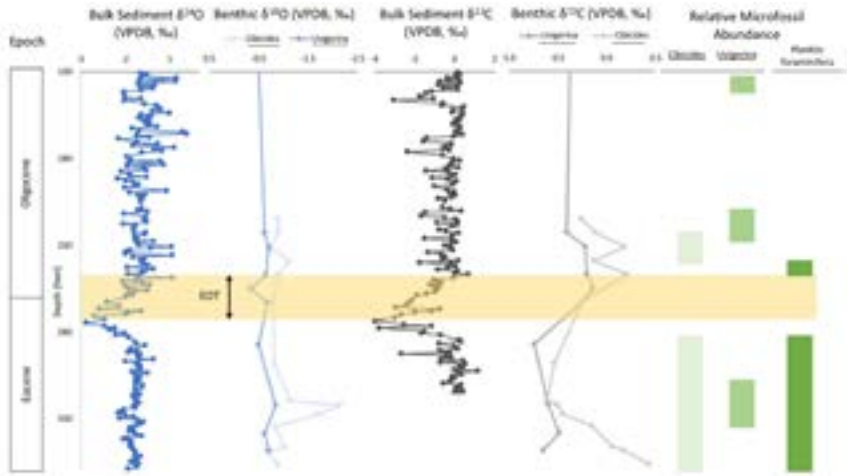

Figure 1. Palaeoenvironmental change at Mossy Grove during the late Eocene and early Oligocene. Bulk stable isotope data (De Lira Mota pers. comm.) and new benthic foraminifera stable isotope and selected foraminiferal assemblage data (generated from the 250–300 µm sieve size fraction). Yellow horizontal shaded bar indicates the position of the Eocene–Oligocene transition (EOT). Vertical green bars indicate the relative dominance of selected microfossil groups in the Mossy Grove core.

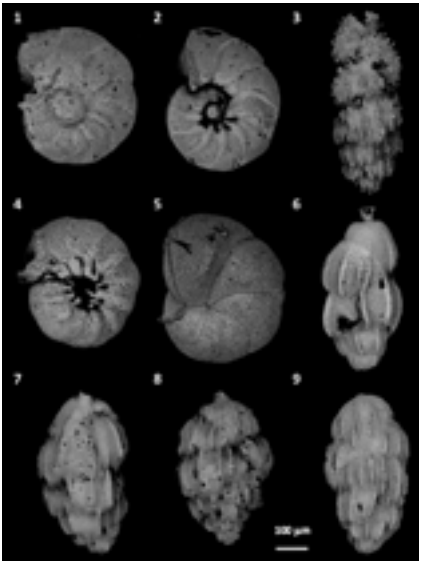

Figure 2. Scanning Electron Microscope images of selected species from the Mossy Grove core run for stable isotope analyses. 1 = Sample MG 348 – Cibicides pippeni, *2 = Sample MG348* – Anomalina costiana, *3 = Sample MG 340* – Uvigerina gardnerae, *4 = Sample MG 338* – Anomalina umbonata, *5 = Sample MG 334* – Cibicides mississippiensis, *6 = Sample MG 322* – Uvigerina cocoaensis, *7 = Sample MG 263* – Uvigerina jacksonensis, *8 = MG 263* – Uvigerina vicksburgensis, *9 = Sample MG 263* – Uvigerina danvillensis. *Species identification follows Bandy (1949).*

increase in values across the EOT, but rather remain relatively stable throughout the record. We interpret this as progressive bottom water warming as sea level falls, within this marginal shelf-sea subtropical location, which counteracts global cooling and ice-volume effects on benthic $\delta^{18}O$ values. These new data will be combined with the efforts from other academics in the department to produce an integrated high-quality dataset documenting the response of multiple ecosystem components to climate change through the late Eocene and earliest Oligocene.

Acknowledgements

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Investigating the palaeotopography and variations in Ecology of Rhaetian Bristol using the Westbury Formation bone bed

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The rocks of the Bristol district in SW England include two exceptional fossil deposits of Late Triassic age, the marine bonebeds of the Westbury Formation, and the largely terrestrial fissure fill deposits of the Triassic palaeokarst (Whiteside *et al.* 2016). Well-known taxa from these deposits include the 'Bristol Dinosaur' *Thecodontosaurus* from the fissure fills and the only British placodont *Psephoderma*, together with diverse sharks, bony fishes and other marine reptiles from the Westbury bone-bed (Nordén *et al.* 2015). The bone-beds can be dated using marine invertebrates and microfossils, but dating the fissure fills has proven difficult, with ages from Carnian to Toarcian being proposed (Whiteside *et al.* 2016), a span of 50 Ma.

Many of the fissure faunas contain fossils that are also common components of the Westbury bone-beds, such as *Severnichthys* teeth (Whiteside *et al.* 2016), and rare terrestrial elements from the

Westbury are often from taxa common in the fissure fills like sphenodontian fragments (Nordén, *et al*. 2015). These similarities, along with palynomorph data (Whiteside and Marshall 2008), suggest the fissures and the Rhaetian bone-beds were coeval. However, some of the fissure fill localities are in the vicinity of bedded Rhaetian strata, so there is a conundrum in trying to explain how marine and terrestrial fossil faunas were deposited at the same time in the same area.

According to Whiteside *et al*. (2016), the fissure fills were deposited as a mix of flank margin caves on small carbonate islands and neptunian dykes formed in the shallows around these islands. These carbonate islands were composed of the same folded Carboniferous rocks that form the backbone of the Mendip Hills today and are spectacularly exposed in the Avon Gorge. The presence of bedded Rhaetian sediments at similar altitudes to the fissure fill localities suggests that some fissures would have been underwater during the Rhaetian, so they must have been deposited earlier. This is the kind of problem that stimulated my project, to create a 3D model of the island chain, using a GIS software, to test whether the fissures could have been filled during the Rhaetian.

I used ArcGIS software to make 3D models based on three primary data sources: stratigraphic sections from the literature, borehole scans from the BGS archive, and mapped geological contacts. The mapped geological contacts were extracted from a digital version of the BGS 50,000 geological map series. The vertices-to-point function was used to convert these contacts into points. The BGS licensed Nextmap digital terrain model was used to add height information to each point with the 3D analyst add-on. Surfaces were generated using the spline-with-barriers function, with Mesozoic faults being used as the barriers. I used the 3D data to generate four surfaces: the top of the Palaeozoic, the top of the Mercia Mudstone Group, the base of the Westbury Formation and the top of the Cotham Formation. Areas where the Palaeozoic surface is higher than the other surfaces represent areas of exposed Palaeozoic strata, either highlands or islands depending on the environment.

The primary result of this study was a series of 3D models and corresponding 2D maps that show the changing environment in the Bristol district across the Rhaetian transgression. The maps show the transition from the arid continental basin bracketed by carbonate highlands in the time of the Mercia Mudstone Group (Figure 1A) to a shallow sea with multiple carbonate islands during the time of the Westbury Formation (Figure 1B), and then showing the continuing transgression through to the time of the Cotham Formation (Figure 1C). A map of the current Palaeozoic outcrops is included for comparison (Figure 1D). The fissure fill localities along with described bone-bed localities were plotted on the map (Figure 2).

According to the model, the terrestrial fissure fill localities were on islands of the archipelago, while the Holwell locality was just off the coast. This fits with the model outlined by Whiteside *et al*. (2016) that this fissure was a Neptunian dyke rather than a terrestrial fissure fill. Furthermore, many of the fissure fills were submerged by the time of deposition of the Cotham Formation, as can be seen in Figure 2. This provides an additional line of evidence that these fissure faunas must have accumulated in the karst caves in the early Rhaetian. A notable outlier is the fissure at Windsor Hill which sits far from the shoreline and is much higher than the Westbury and Cotham surfaces. This fissure contained a monotypic fauna consisting entirely of the tritylodontid *Oligokyphus* and has been described as a Neptunian dyke. Perhaps this fissure is younger than the others in the study area, and was deposited at a time of much higher sea level.

This was a fun project, being able to reconstruct a landscape in detail using all the geological data about the Bristol district accumulated since Buckland and Conybeare first drew the Aust section, with the red Mercia Mudstones capped by black and grey Rhaetian and Jurassic, back in the 1820s. The new 3D model of the Bristol area during the Late Triassic reveals the structure and geography of the Rhaetian islands. I can now demonstrate that it is geographically possible for the Westbury Formation bone-beds and the fissure fills to be deposited coevally. Further, it is unlikely that these fissures were deposited later, except for the Neptunian dykes at Holwell and Windsor Hill. Now the structure of the island chain has been confirmed, and the sizes and spacing of the islands determined, it should be possible to explore how the detailed biogeography affected evolution, as the early dinosaurs and sphenodontians hopped and swam from island to island through tropical seas.

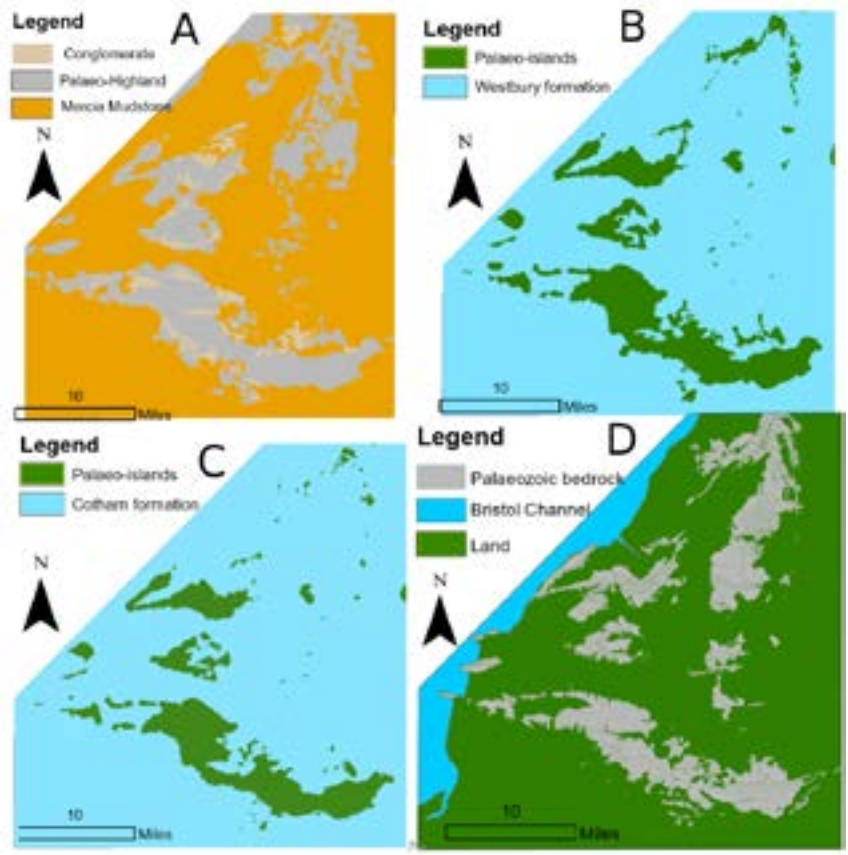

Figure 1. Maps showing the transition from (1A) the arid continental basin bracketed by carbonate highlands to (1B) a shallow sea with multiple carbonate islands and then (1C) a continuing transgression. A map of the current Palaeozoic outcrops is included for comparison (1D).

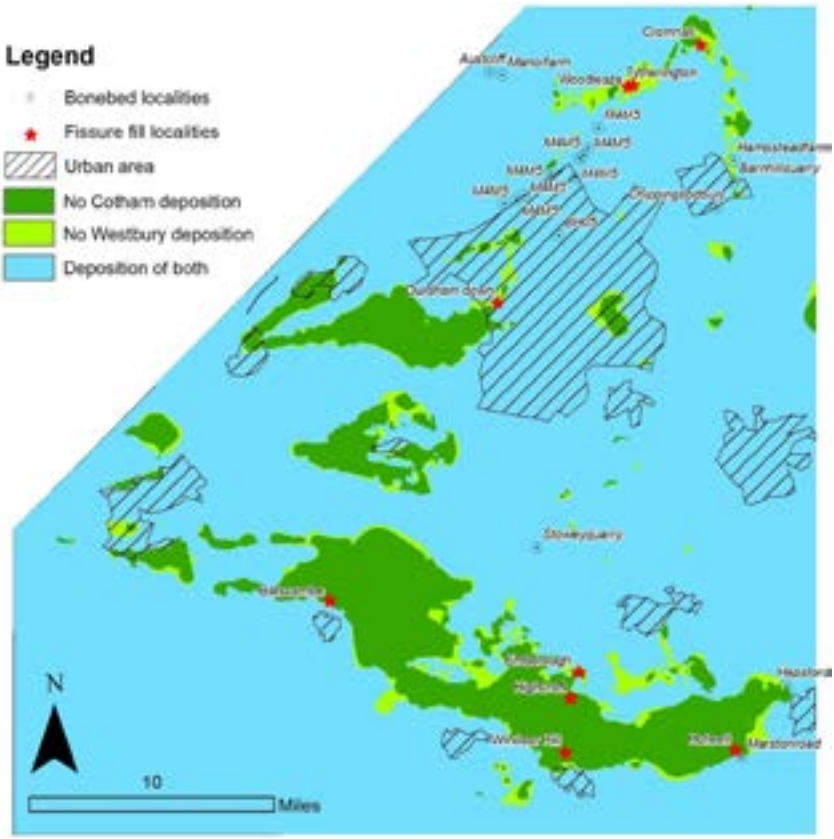

Figure 2. Map with localities of the fissure fill and bone-bed added.

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What happened to Pseudosuchia? Exploring the effects of past environmental change on a once diverse clade

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Introduction

Many members of the enigmatic order Crocodylia are at risk of extinction, with five species being classified as critically endangered and four as vulnerable (IUCN, 2019). Hunted for their skin and persecuted for posing danger to human populations, modern crocodilians may also be threatened by ongoing climate change. Many species reside in low-lying areas, meaning that rising sea levels associated with global warming may irreversibly damage the habitats on which they depend.

Crocodilians are the only living representatives of the larger clade Pseudosuchia, a lineage that emerged in the Triassic and occupied a variety of habitats and niches. They included large terrestrial carnivores such as the rauisuchids, heavily armoured herbivores like aetosaurs, the ocean-going thalattosuchians and a host of other diverse forms. Modern crocodilians, meanwhile, are more ecologically and morphologically constrained than their extinct counterparts and also exhibit a significantly reduced species richness compared to the past. There is growing evidence for climate change as a major driver of diversity (Claramunt and Cracraft 2015; Davis *et al.* 2016; Tang *et al.* 2018). Previous work (Mannion *et al.* 2015) has revealed a relationship between global warming and diversification in Pseudosuchia using a taxon-based approach.

This project is the first to explore the evolutionary responses of Pseudosuchia to climate change within a phylogenetic framework and also uses novel methods to separate out the drivers of speciation and extinction, as opposed to solely net diversification. The primary objective was to ascertain whether climate change drove diversification dynamics in Pseudosuchia, and the impact of ecology on those dynamics.

Methods

We constructed the largest phylogeny of Pseudosuchia to date, using the metatree approach (Lloyd *et al.* 2016). Running the data in TNT v1.1 (Goloboff *et al.* 2008) culminated in 1,320 trees of length 1,100,897. We used a random sample of 10 % of these MPTs to infer a Maximum Agreement Subtree (MAST) using PAUP* 4.0a165 (Swofford, 2019). The final phylogeny contained 536 taxa.

The Paleobiology Database (<**https://paleobiodb.org**>) and scientific literature were used to gather occurrences for each taxon to time-calibrate the tree. Age ranges were standardised to the GSA Time Scale v5.0 (Walker *et al.*, 2018), with regional ages being converted to their equivalent age in the global time scale. In instances where these crossed the boundary of two global ages, the range of the regional age was substituted for the lower boundary of the oldest and the upper of the youngest global age. Prior calibration was achieved with the program BEAST2 v2.6.0 (Bouckaert *et al.* 2019). Molecular data provided by Oaks (2011) were used to calibrate the divergence of extant lineages, whilst the earliest known occurrence was implemented for extinct taxa. Node tips were dated in R to the midpoint of the last occurrence of each taxon.

We used FossilBAMM (Mitchell *et al.* 2019) to estimate speciation, extinction and net diversification rates for the Pseudosuchian tree and correlated these with ocean surface temperature (Veizer *et al.*

1999), pH (Ridgwell 2005), CO_2 (Bergman *et al.* 2004) and sea level (Haq *et al.* 1987) through deep time over a total of 9,001 simulations. We subdivided the tree into terrestrial, marine and freshwater taxa after an exhaustive literature search and performed these correlations with the resultant subtrees, to explore whether responses were ecologically constrained.

Results

Pseudosuchian Phylogeny

The major successive clades within Pseudosuchia (Figure 1) were found to be monophyletic with the exception of Loricata and Crocodylia. *Dagasuchus* and *Mandasuchus* were more basal than Poposauroidea, placing them outside of Paracrocodylomorpha, and Sebecosuchia was recovered within the larger clade of Notosuchia. *Sabresuchus* was recovered as a member of Atoposauridae, which itself was resolved as the most basal neosuchian taxon. Pholidosauridae was found to be paraphyletic and instead represents two distinct lineages, one limited to *Pholidosaurus* and the other containing *Elosuchus* and its relatives. Mekosuchidae was resolved as a valid taxon due to Crocodylidae being defined as the last common ancestor of *Crocodylus niloticus* and *Osteolaemus tetraspes* and its descendants (Brochu 2003), with Mekosuchidae being basal to both. The 'thoracosaurs' *Thoracosaurus* and *Eothoracosaurus* did not form a clade, and rather represented a paraphyletic group on the Gavialinae line.

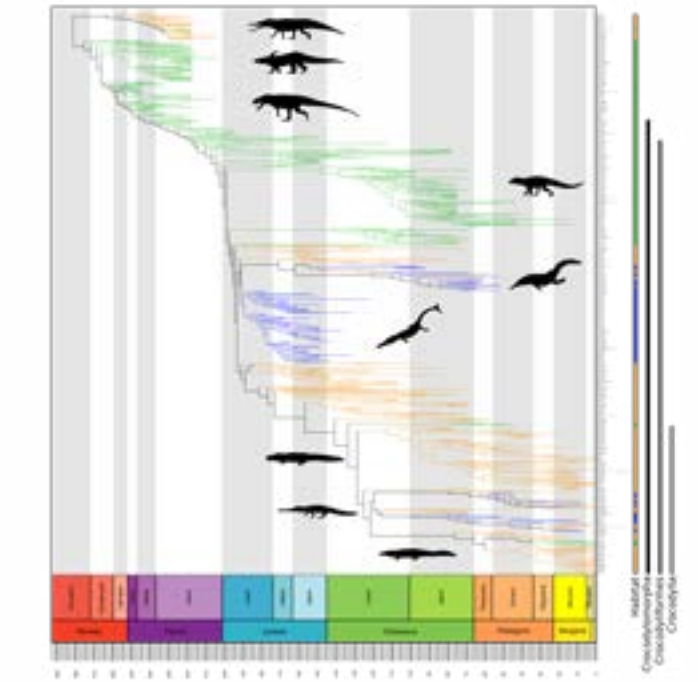

Figure 1. Phylogeny of Pseudosuchia scaled to geological time, displaying ecological characterization. Blue signifies marine taxa, yellow shows freshwater taxa and green are terrestrial taxa. Labelled from top to bottom, silhouettes represent the following major groups: Phytosauria, Aetosauria, Rauisuchidae, Notosuchia, Tethysuchia, Thalattosuchia, Alligatoroidea, Gavialoidea, Crocodyloidea. Silhouettes by Scott Hartman, Gareth Monger and Nobu Tamura, used under the Creative Commons Attribution 3.0 Unported <**https://creativecommons.org/licenses/by/3.0/**>.

Environmental Correlations

We found evidence for global warming and lower sea level as drivers of diversification. For marine taxa there is a significant relationship between warming and both speciation (Figure 2a) and net diversification rate (Figure 2b). There was no relationship found between any of the climate variables and extinction rate for marine taxa. In contrast, lower sea levels were found to be the strongest driver for both speciation (Figure 2c) and net diversification (Figure 2d) in terrestrial taxa. To a lesser extent, global warming had a significant effect on speciation (Figure 2e) and net diversification (Figure 2f). As with marine taxa, there were no significant relationships between any of the tested climate variables and the rate of extinction in terrestrial pseudosuchians. There were no significant relationships found between any environmental factors and diversification dynamics for freshwater taxa.

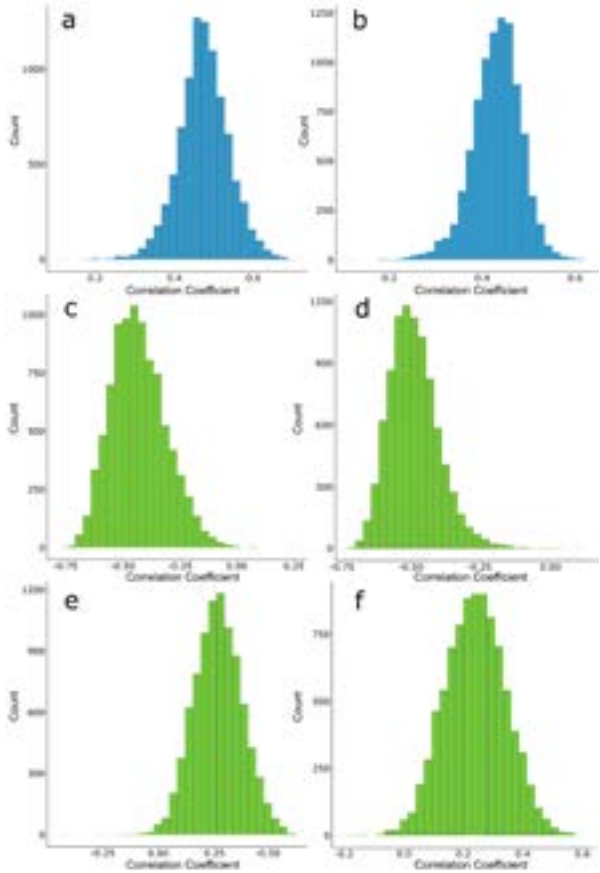

Figure 2. Histograms of correlation coefficients between (a) speciation and temperature in marine taxa, (b) net diversification and temperature in marine taxa, (c) speciation and sea level in terrestrial taxa, (d) net diversification and sea level in terrestrial taxa, (e) speciation and temperature in terrestrial taxa, and (f) net diversification and temperature in terrestrial taxa. All histograms show correlations between the listed environmental factors and 9,001 diversification simulations.

Discussion

The response of Pseudosuchia to environmental change is ecologically constrained, with marine and terrestrial taxa responding to different drivers. Temperature as the strongest environmental driver in marine taxa contrasts with the findings of Mannion *et al.* (2015), who found no relationship between temperature and diversification for marine taxa, but instead agrees with Martin *et al.* (2014) who suggested this trend was due to their largely ectothermic nature. Lower sea levels as a strong driver of speciation and net diversification in terrestrial taxa was also found by Mannion *et al.* (2015) and could be due to the creation of new environments that these organisms could colonise, as observed in the last glacial maximum (Mead *et al.* 2002). Furthermore, whilst speciation and net diversification seem to be driven by abiotic factors, no environmental drivers were correlated with extinction rate, which may suggest that extinction is instead predominantly driven by biotic turnover or competition. This would fit with the observation that several lineages disappear at the Triassic–Jurassic boundary, a time of rapid biotic turnover (Lucas and Tanner 2015) that saw the extinction of all non-crocodylomorph pseudosuchians. In this regard, the novel ability to investigate speciation and extinction rates individually, in place of net diversification, has allowed us to disentangle the impact of biotic and abiotic factors on pseudosuchian clade dynamics. A clear insight into how these may independently affect a clade's diversity is vital if we wish to use the geological record to understand drivers of modern biodiversity.

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Testing the biogenicity of ancient stromatolites using magnetic susceptibility

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Introduction

Stromatolites are layered, domed, sedimentary structures that typically form in shallow marine environments. Stromatolites represent some of the oldest putative evidence for life on Earth, making their first appearance in the geological record during the Archean (~3.5 Ga) (Reid *et al.* 2000). These ancient stromatolites are thought to have formed under the biological influence of microbial mats, which are complex layered communities of microbes. However, stromatolite-like morphologies can form from abiotic processes such as chemical precipitation, sedimentation and random noise (Grotzinger and Rothman 1996), and a lack of preserved microbial fossils leaves the biogenicity of many ancient stromatolites open for debate.

Recently, a new methodology for distinguishing between abiotic and biotic stromatolites was proposed, using the distribution of magnetic minerals (Petryshyn *et al.* 2016). In shallow marine environments, fine detrital grains, including magnetic particles, are suspended throughout the water column, eventually settling upon growing stromatolites. If the loose sediment falls on a steep-sided (>~45°) stromatolite with no microbial mat present the sediment will slide off, resulting in magnetic particles building up only on the apex and base of a stromatolite lamination; this is known as the angle of slide relationship. However, if a microbial mat is present, the sticky biofilm will trap and bind detrital magnetic grains in excess of the angle of repose (>45°) (Petryshyn *et al.* 2016). Filamentous microbial communities are known to trap sediment up to an 180° angle (Petryshyn *et al.* 2016). Hence, the variation in the concentration of magnetic particles throughout laminae can be used as an indicator to distinguish between abiotic and biotic formation processes. The notion of using magnetic susceptibility as a biosignature has been previously ground-truthed in laboratory experiments by Petryshyn *et al*. (2016).

Methods

Magnetic susceptibility was measured across a selection of ancient stromatolites of unknown biogenicity. Stromatolites were first cut perpendicular to bedding and slabs were polished so that individual laminae were easy to identify visually. Powdered samples were drilled systematically at different points along the individual stromatolite laminations using a Dremel 3000 drill. A diamond drill tip was vital in this process as no metal could come into contact with the sample. Any metal cross contamination would provide inaccurate results. Once the powder samples were taken, they were immediately placed into individual 8 cm^3 plastic cubes for analysis. The magnetic susceptibility for each sample was measured ten times using a KLY-4 Kappabridge. The 'mean' of the results and standard deviation were calculated. The sample sizes (~0.2 g) were challenging for the KLY-4 Kappabridge, pushing it close to its sensitivity limit. Therefore, it was essential to check the standard deviation to ensure the ten tests correlated with one another, ensuring the reliability of future data processing. All statistical analyses were run on the log of the mass-normalized magnetic susceptibility for each sample. We focused our analyses on two stromatolites in particular, a Proterozoic conophyton from Svalbard, Norway (Figure 1) and the upper Triassic 'Cotham Marble'

stromatolite from the UK (Figure 2), both of which contained relatively high angle laminations and which were among the larger samples in the collection, thereby enabling the drilling of larger masses of powder.

Figure 1. Conophyton stromatolite from Norway. Powder samples were drilled across laminations.

Figure 2. Cotham Marble stromatolite. Powder samples were drilled across laminations.

Results

Early results suggest there are no consistent spatial patterns in the magnetic susceptibility of the Cotham Marble stromatolite, suggesting it was most likely formed by biotic processes. The Cotham Marble was deposited during the Triassic–Jurassic mass extinction interval; if it was formed under the influence of microbial life this could support the idea that microbial life thrived while benthos was suppressed during the extinction (Ibarra and Corsetti 2016).

The conophyton stromatolite from Svalbard had the greatest along-lamination variation of magnetic susceptibility. While controlling for the high variability in magnetic susceptibility from lamination to lamination, patterns of magnetic susceptibility were investigated in the stromatolite using Rstudio. The statistics indicate that the stromatolite apex has statistically significantly higher magnetic susceptibility than the steep-angled stromatolite sides. This means that there is a strong possibility the laminations were formed by abiotic processes. However, the pattern is noisy (perhaps itself an indication of the involvement of biology in stromatolite genesis) and further analysis is required before this can be confirmed.

An additional powder sample was taken from the Svalbard specimen and tested using thermomagnetic measurements. The purpose of this test was to establish how the magnetic minerals react to temperature, indicating what magnetic minerals may be present. The results indicate that the sample is primarily diamagnetic (carbonate minerals) with a trace of ferromagnetic minerals present (likely a magnetite) (see Figure 3).

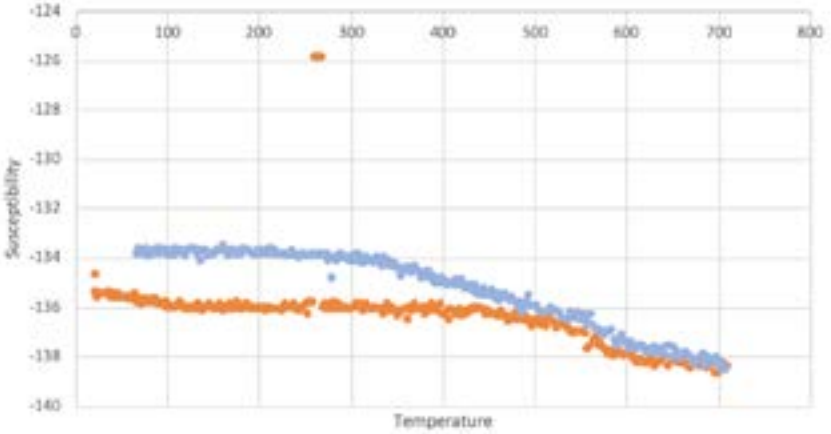

Figure 3. The orange data illustrate how the magnetic minerals react to a temperature increase. The blue dataset represents how the minerals reacted as they were cooled down. That the curves are not identical indicates that there were thermally-induced mineralogical changes during the experiment. Overall negative values are due to the diamagnetic response of carbonate. The relatively flat orange curve suggests a trace ferromagnetic presence.

Next steps

To achieve conclusive results future work includes expanding the dataset to give the statistical tests we used greater power. In addition, we will conduct XRD analysis to further identify the magnetic mineral content of the specimens. A thin section will be taken to analyse under the microscope and

look for microbial fabrics and fossils. Key points and updates will be posted on my blog at <**www.omnisterrascientia.com**>.

Acknowledgements

I would like to give special thanks to my research supervisors Sarah Greene, Carl Stevenson and Marco Maffione for their constant support throughout this project. I would also like to thank both Sarah Greene and Tom Dunkley Jones for donating stromatolites to this research, Lydia Greene for guidance on statistics and Ivan Sansom for showing me how to correctly prepare the specimens for analysis.

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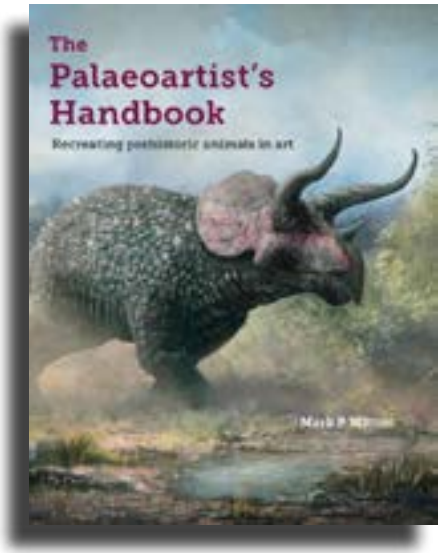
Book Reviews

The Palaeoartist's Handbook: Recreating Prehistoric Animals in Art

Mark P. Witton. 2018. Crowood Press Ltd., UK. 224pp. £22.00 paperback.
ISBN: 978-1-78500-461-2.



Dinosaurs, even given the wealth of information we now know about them, are still tricky beasts to draw. They demand great attention to detail, an understanding of extinct anatomy, locomotion, dermal integument, musculature and, with extraordinary advances in science, sometimes even their colour. Nor did these animals, now long extinct, live in isolation. They were denizens of vast and complex ecosystems, intricately intertwined with the other equally strange plants and animals with which they shared their world.

If we add to this mix their often extreme proportions, the ever-changing interpretative research with which the artist must be familiar, and a whole assortment of other challenges that are not relevant to drawing contemporary fauna, drawing dinosaurs and other extinct organisms with a degree of accuracy and scientific credibility is hard.

This handy guide serves to address that, offering the novice and professional alike a functional breakdown of the knowledge, approach, methods, research and rigour required to think properly about this process.

With the advent of digital technologies opening this genre to a growing number of amateur artists, this perhaps, has never been more relevant. I foresee this book quickly becoming the 'go-to' guide for any aspiring palaeo-illustrator.

The Palaeoartist's Handbook, the first of its kind of which I am aware, offers a unique resource for the artist wishing to enter this field, and will, I believe, become a benchmark for scientific rigour and the artistic sensibility required to produce this highly disciplined art style with accuracy and authenticity.

Mark Witton (University of Portsmouth) has previously (2013) authored and illustrated an excellent book on the evolution of pterosaurs. He has likewise lavishly illustrated this new publication, along with other outstanding artists in this field. At 224 pages this is no lightweight volume, and seeks to cover much more than reconstructing dinosaurs alone.

In addition to artistic techniques, the book addresses the history and pitfalls of palaeontological interpretation, and offers the student or reader a reasonable overview and understanding of nomenclature, cladistics, stratigraphic context, palaeobotany and sedimentology, as well as considerations of anatomy and musculature. It covers many of the things which must be understood in order to place the subject in context when portraying the life appearance of a wealth of extinct organisms.

This book offers a sound platform to the prospective palaeo-artist. It suggests a practical approach to sourcing and interpreting data, and an introduction to vital scientific principles.

As an excellent artist himself, the author gives practical guidance on such important considerations as composition, relevance, mood and atmosphere, which can be easily lost in scientific interpretations, and draws on many examples to illustrate his narrative.

In summary, this is a fine and long-awaited addition to the field. For the non-artist with a general interest in palaeontological illustration, this will certainly be an entertaining and revealing read. For the scientist, it will give an insight into the study and attention invested by artists into this related discipline. For the artist, prospective or established, this will be a valuable and supportive addition to their library.

Highly recommended.

Jon Hoad
Director of Art of Ancient Life Limited, PalAlba

Another Primordial Day: The Paleo Metal Diaries

Mats E. Eriksson. 2019. 456pp. PMET Publishing House, Malmös.
SEK 195.00 hardcover. ISBN 978-91-519-0456-6.

I must admit that I am profoundly biased in my review of this wonderful and colourful book: I feel a special connection to the author, although I don't think I have ever met him. This connection is rooted in our shared weak spots for heavy metal (including the rougher kinds), palaeo-art including 3D-life reconstructions and, last but not least, palaeontology, of course.

Most of you probably read about Mats (the author of the Paleo Metal Diaries) before, either because of his numerous papers in *Nature* and its sub-journals, *Palaeontology*, and other scientific journals or because you saw some report about species he named after heavy metal stars or in the context of the rock fossils-exhibitions[1]. In any case, for those of you who have never heard or read about him, here is a short version of his curriculum vitae: Mats is professor at the Department of Geology at Lund University. He has published nearly 100 research articles on invertebrate and vertebrate palaeontology as well as geology (mostly Paleozoic). Equally important in this context: Mats plays heavy metal himself (guitar) and produced several heavy metal records. Finally, he is friends with some artists who produce palaeo-art in a broad sense. This includes the producer of some of the finest palaeo-models worldwide, Copenhagen-based Esben Horn, and the world-renowned heavy metal cover-artist Joe Petagno, who created the cover art of the book.

[1] Editor's note: see the "Fossils for Metal Heads" article on page 54 in this issue.

In a way, this short portrayal of Mats reflects the content of the book, which is a fun read and not only for those who share his interests. The book is subdivided into Act One ("Dead stuff and deep time") and Act Two ("Clash of worlds"). While Act One provides an entertaining introduction into palaeontology and the evolution of life, Act Two explores the reflection of palaeontological topics and objects in Heavy Metal music (*i.e.* lyrics), cover art and taxon names featuring heavy metal artists. Additionally, Mats (self-)portrays his endeavours in palaeontological outreach such as the literally 'touring' exhibition *Rock Fossils*.

The exhibition *Rock fossils* deserves its own paragraph because I assume that it became an important trigger for the writing of this book. *Rock fossils* kicked off in 2013 at the Geomuseum Faxe on Sjaelland, Denmark. This exhibit is linked to the fortunate combination of the deep friendship between Esben Horn and Mats on the one side and Mats' tendency to name terrifying Paleozoic worms after famous stars of the Heavy Metal scene such as Lemmy Kilmister from Motörhead or Alex Webster from Cannibal Corpse, on the other. What happened after the success of the exhibition in Faxe was probably rather unexpected to the organizers: the exhibition started to migrate through natural history museums in Europe including Oslo (Norway), Copenhagen (Denmark), Bern (Switzerland), as well as Dotternhausen, Wacken and Chemnitz (all in Germany) and Luxembourg. Over time, the exhibition grew, including an increasing number of excellent models made by Esben Horn's company 10 Tons and several new taxa named after rock stars. In addition, these exhibitions are always accompanied by live gigs of rock and heavy metal bands (in a broad sense).

"Another Primordial Day: The Paleo Metal Diaries" is a lovely book for those who enjoy unconventional ways of reaching out to the public. Although heavy rock is not that young any more, it still enjoys a vast number of fans of all ages worldwide and thus it is not an absurd idea to combine rock 'n' roll and palaeontology in order to reach out to the public. Mats is a skilled writer who manages to entertain the reader even if much of the scientific content might already be known to many of you. The book is richly illustrated with photos of fossils, rock stars, cover-art of records *etc*. I also enjoyed how much love was put into the details of this book. For instance, many chapters begin with a line from the lyrics of a rock song; many illustrations have a dark or morbid 'aura'; the overall layout is somewhat reminiscent of classical fanzines *etc*.

To sum up, this is not a book to learn more about palaeontology for our community, but it is an excellent example of how to reach out to the public in unconventional ways. It is entertaining on many levels, at times funny, sometimes bizarre and teeming with Mats' deep love for the three main topics: palaeontology, heavy rock and palaeo-art. Ultimately, it is the 'rock' in both senses that rocks and brought forth this gem of a popular science book.

Christian Klug
Paläontologisches Institut und Museum, Universität Zürich

Books available to review

The following books are available to review. Please contact the Book Review Editor, Tom Challands (e-mail <**bookreview@palass.org**>), if you are interested in reviewing any of these.

- *The Missing Lynx: The Past and Future of Britain's Lost Mammals*, by Ross Barnett.
- *The Dinosaurs Rediscovered: How A Scientific Revolution Is Rewriting Their Story*, by Michael Benton.
- *History of Life*, 5th Edition, by Richard Cowen.
- *Fossils Of The Milwaukee Formation: A Diverse Middle Devonian Biota From Wisconsin, USA*, by Kenneth C. Gass, Joanne Kluessendorf, Donald G. Mikulic and Carlton E. Brett.
- *Across the Bridge*, by Henry Gee.
- *Beyond Extinction: The Eternal Ocean. Climate Change & the Continuity of Life*, by Wolfgang Grulke.
- *Fossil Frogs and Toads of North America*, by J. Alan Holman.
- *Trilobites of the British Isles*, by Robert Kennedy and Sinclair Stammers.
- *Fossilien im Alpstein: Kreide und Eozän der Nordostschweiz*, by Peter Kürsteiner and Christian Klug.
- *William Smith's Fossils Reunited*, by Peter Wigley (editor) with Jill Darrell, Diana Clements and Hugh Torrens.

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Careers Q & A

Professional palaeontologists in the wider world

After doing a PhD at the University of Oxford (2014–2019), Harrie Drage now works as a Development Editor in Secondary Science Education at Oxford University Press (2019 – today).

Q1: When you were a child, what did you want to be when you grew up?
I absolutely always wanted to be a palaeontologist, from about age eight. It was that or herpetology, and I was determined to get there. It was all I talked about, and I chose all of my hobbies and my qualifications around becoming a palaeontologist.

To be honest, this is what made the decision to leave academia so difficult – it had been my only real career aspiration, and everything I did until that point had been leading up to doing a PhD.

Q2: How did you first get interested in palaeontology?
I spent a large portion of my childhood watching every documentary going on palaeontology and zoology. The scientists presenting them were my childhood heroes.

After that first sparked my interest, I dragged my parents to every natural history museum possible. I'm from Kent in the southeast of the UK so we went to London regularly, and each time I'd make them take me to the NHM, even though I could already tell them about all the exhibits. Further dream trips to places like Drumheller in Canada really cemented my aspirations. Fortunately, I could also spend a lot of time on the coast, and curated massive fossil collections that I'd gone beachcombing for.

Q3: What is your favourite fossil and why?
The amazing fossils of horseshoe crabs preserved at the end of their death trails from the Solnhofen Limestone of Germany. Fossils that preserve behaviour, as well as morphology, are so valuable to research, and also evoke a story.

Q4: What made you pursue your current job?
While I love research, I had decided I didn't want to stay in academia. Having made that choice, I then thought about all of the skills and tasks I enjoyed most from research, and searched for other careers that would also fit with these.

Publishing ticked all of the boxes, and I felt I also knew a bit about the sector having been involved in the publishing process numerous

times as an author. When a job in the Secondary Science Education team at Oxford University Press (OUP) came up, this also filled my desire to put my scientific background to use, and to use my skills to have a broader impact in science. After all, improving science education is the first step to creating enthusiastic and excellent researchers.

Q5: What are the main responsibilities of your job?
Being a senior editor at OUP is extremely varied. I work to produce top-quality resources (print books, and varied online resources) across biology, chemistry and physics, covering teaching for students aged 11 to 18, and across several exam boards.

On any day, I might carry out some reviewing, editing, proofreading or content writing for a resource or book. I will also work directly with many authors and freelancers, and other OUP teams, to commission and produce this content.

My job involves a lot of project management and scheduling, handling other stakeholders in a professional manner, and a huge amount of problem-solving. The team works to short, dynamic schedules, and on many different projects at once with lots of different people, creating a fast-paced and varied environment.

Q6: What gives you the most satisfaction in your job?
On a finer scale, having positive interactions with my authors and freelancers is always motivating and enjoyable. I also greatly enjoy the process of seeing unedited manuscripts transformed into error-free designed pages.

On a broader scale, creating resources that help teachers teach and students learn. Improving science education is crucial to solving many of the wider problems faced in the world today, so if I can motivate, inspire and help a few people with my work then that makes all the difference.

Q7: What are the worst things about your job?
The schedules that we work can sometimes feel like too much and overwhelm you – pretty standard for most businesses these days. For this reason, it's sometimes difficult to enjoy the fast-paced nature of the job.

I also deal with corrections to our books and resources, and often customers who write in with these are not overly kind and don't always behave like there is someone on the other end of their complaint.

Q8: What has been the best career advice you have received?
I think just others telling me that if a job sounds interesting to me, I should apply. It's not really about how many of the required skills for a job you fulfil, but much more about whether you can learn them and apply your other learned skills, and about demonstrating this in interviews. Never think you've no chance of getting a job before you've applied – I was absolutely certain they wouldn't hire someone with my experience for this job, but here we are!

Q9: What skills does it take to be successful in your job?
A huge part is being able to take the initiative, get things done, and solve problems. Otherwise, excellent time management, project management, editorial skills and communication, plus the ability to work on your own and with lots of different people.

Q10: Do you have any tips for students who would like to take a similar career path?
If you think you'd be interested in a job in publishing but don't yet fulfil the criteria, go for it! I felt certain I wouldn't get my current job because I had no experience in the education sector. If you want to work in publishing, try to find out how the different firms operate and what the different job titles might mean – editors work very differently in different firms. OUP is still quite hands-on with content, so I read a lot of science, but in other firms the editors are almost entirely project managers. Try to also gain some tangible experience that shows off your editorial skills – I do editorial work for a charity in my spare time.

Q11: Are there any major obstacles to being successful in a career like yours?
Publishing is strange because it is predominantly female – this removes a lot of the barriers that other careers (and definitely academia) have. However, there's still a big problem with equality at the senior management levels, and this can become an obstacle later on.

Q12: What's the best thing about your job?
It's different every day, I work on interesting science (some of which I never learned while at school) with lots of different people and I get to make a difference to students' education and teachers' jobs. Feeling like I have an influence in the lives of students and teachers in science is what really motivates me at work.

Q13: What are your future ambitions?
Dreaming big, I'd like to be the head of publishing activities for a science NGO – I want to work on communicating science policy strategy, either broadly or in education.
I was quite recently promoted to my senior editorial role so now get to be more involved in education strategy, and I'd like to continue gaining this type of experience.

Find out more about Harrie:

through her personal website <**https://harrietdrage.wordpress.com**>

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We need to raise £175,000 to create this permanent artwork by renowned artist Hazel Reeves. We are planning to raise this money via *PEOPLE POWER* launching a crowdfunder page as soon as we have enough pledges.

We'd love *YOU* to be a part of this innovative way of helping us to recognise Mary Anning's remarkable achievements. Please visit **www.maryanningrocks.co.uk** and pledge an amount - every penny counts, and we can't do this without you!

MARY ANNING ROCKS

THANK YOU!

Find us on

www.maryanningrocks.co.uk

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TAXONOMY/NOMENCLATURE UPDATE

This publication is now registered on ZooBank and is thus deemed to be valid for taxonomic/nomenclatural purposes. However we request contributors (especially those contributing grant reports) not to include names of new taxa in their reports.

Newsletter copy

Information – whether copy as such or Newsletter messages, review material, news, emergencies and advertising suggestions – can be sent to Graeme Lloyd, e-mail <**newsletter@palass.org**>). The *Newsletter* is prepared by Nick Stroud, and printed by Y Lolfa, Talybont, Ceredigion.

Deadline for copy for Issue No. 103 is 10th February 2020.

Palaeontological Association on the Internet

The Palaeontological Association has its own pages on the World Wide Web, including information about the Association, and copies of the *Newsletter*. Internet Officer Alan Spencer can be reached by e-mail at <**webmaster@palass.org**>. The locator is <**http://www.palass.org/**>.

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